BIOLOGICAL METHODS OF PEST CONTROL

Proceedings of the Southern Regional Seminar

NOVEMBER 21—22, 1988

Edited by

K. VIJAYALAKSHMI

PPST FOUNDATION

(Patriotic and People-Oriented Science & Technology Foundation)

6, Second Cross Street, Karpagam Gardens

Adyar, Madras 600 020

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PPST FOUNDATION

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— evolving the basis for a science and technology having its roots in the Indian scientific and technological traditions and oriented towards meeting the needs of the Indian people.

— evolving an outline of how a self-confident and functional Indian society with its distinct Indianness can emerge around a nucleus of concepts, techniques and structures drawn from the functional aspects of Indian culture and civilization.

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PREFACE

It is commonly held that Green Revolution has made India self-reliant in agricultural production. But after Green Revolution, dependence of the agricultural sector on foreign inputs has increased in diverse ways. While the Government has to depend on foreign countries for a large proportion of the new requisites of agriculture, the agriculturist has to depend even more on the Government and industrial sector. There is an increased dependency all around for tangibles like fertilizers, pesticides, seeds and also an intangible external dependence for knowledge of the agricultural processess. The farmer who was an expert in agricultural technology has in one sweep been reduced to dependency on all fronts. He has had to look to experts allround. PPST has been concerned about this and has brought out several articles which have appeared in the pages of our Bulletin.

In view of the intensive cultivation of several crops in the country in the recent past, many minor pests and diseases have become major ones besides the problem of certain new pests and pathogens. Very often these pests and diseases are not amenable for check by use of synthetic pesticides alone. In the last few years interest in "traditional" pest control methods has been growing largely because synthetic pesticides pose several environmental and human health problems. Sustained agricultural development would be possible when cost effective technologies which are also environmentally safe are adopted. The ill effects of pesticides are only too well known to be talked about here. It is of paramount importance to use the pesticides more judiciously in Integrated Pest Management programmes - in fact use them only in cases where they are an absolute necessity. The PPST Foundation has been engaged in an active research programme for looking into biological methods of pest control and their use in Integrated Pest Management programmes.

In trying to evolve successful integrated pest management programme for various groups and regions, it is important to bring together scientists, farmers and policy makers. Apart from the generally available literature on IPM from books and periodicals, a large amount of this information is available only in the form of non-conventional literature which is mostly in local libraries and institutes and most of them with individuals. This has limited the interchange of knowledge and experience of ideas between scientists, extension workers and farmers and thus

development and implementation of IPM in specific local situations. Therefore an initiative had been taken by our Foundation to bring together scientists, farmers and extension workers for exchange of useful information in a seminar. The response was quite encouraging and a programme of follow up work has been chalked out (for details see Recommendations).

I wish to thank most sincerely all my colleagues at the PPST Foundation for their help in organising the seminar and bringing out this publication. My special thanks are due to Ms. Geetha Varadarajan for the help rendered at various stages in the preparation of the proceedings. We owe our grateful acknowledgement to CAPART (Council for Advancement of People's Action and Rural Technology), New Delhi for the financial support and the various donors and advertisers for the financial help. I also wish to record sincere thanks to the Director of Dhyana Ashram for making the premises available and to all the volunteers for making this seminar a success.

Madras
1st May 1989.

Dr. K. Vijayalakshmi
PPST Foundation.

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Inaugural Session

INTEGRATED PEST MANAGEMENT WITH SPECIAL REFERENCE TO BIOCONTROL*

S.Jayaraj, Vice Chancellor, Tamil Nadu Agricultural University, Coimbatore,

At the outset I would like to thank profusely the Patriotic and People Oriented Science and Technology Foundation, Madras, for having given me the unique opportunity of meeting you and sharing with you some of our experiences on Integrated Pest Management with emphasis on Biological control which is non-polluting, environmentally safe and economically viable. I am glad that this Foundation has taken this theme which is very vital for the production of crops in our country. As you are all aware the Government of Tamil Nadu has launched a special foodgrains production programme this year with increased targets of crop productivity from every unit area and in that process we have to minimize or avoid crop losses caused by pests, diseases, weeds and other organisms. The voluntary organizations involved in this programme as well as the governmental organizations, the universities, the teachers, the students deserve great amount of appreciation. I am happy that this organization is very much interested in the preservation of the ecosystem. We would like to associate our university in a big way with such Foundations so that our technology can be taken to the farmers as speedily as possible.

Now I would like to highlight the problems faced by our farmers. We have to give him reasonable income, more or less stable income whatever may be the problems he may be facing. Very often we find outbreaks of pests and diseases wiping out the crop completely or you find severe weather or climatic aberrations. Floods, droughts and many other physical parameters affect crop growth. So the farmer is losing and this is more so under rainfed conditions. Under dry farming conditions the risks are very great and that is why the farmer is not able to invest money in inputs, that is where the technology has to help him to adopt low cost technology with stabilized income and increased productivity.This is exactly the motto behind

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* Inaugural address.

the TNAU which is precisely spelt out in the TNAU act and the statute that the aim of the university is to improve the living standards of the people living in rural areas. So we have been trying our very best to augment agricultural production as well as animal production at the same time, save the losses caused by pest disease or other agencies in the case of agriculture, veterinary and other fields.

As you may be aware, in our country it has been estimated that every year we are losing crops worth Rs.7,000 crores both in the field and in storage. In the field we find easily about 25 to 40% loss in different crops under various situations and in the storage easily 10 to 15%, but there are cases where near total loss has been inflicted. For instance, if rice blast disease is noticed or red hairy groundnut caterpillar is noticed, we find extensive damage within a short period. That is why we have to continuously monitor the incidence of the pest or disease and then take up the appropriate pest or disease management strategies. So in order to minimize the losses we have to adopt integrated management practices. Now, in addition to this loss there are many insects which transmit diseases in animals as well as in human beings. In human beings alone it has been estimated that 225 million mandays are lost every year in our country due to diseases transmitted by insects. So it is necessary to organize in a large way or on a large scale involving the farmers, the voluntary agencies, the departmental agencies so that we will be able to tackle the problem on a community basis under an area approach rather than piecemeal approach in individual holdings.

Now, the drawbacks of chemical control are already known. Knowingly or unknowingly we are consuming a lot of pesticides-treated produce. We have estimated the residues of pesticides in almost all foods, in vegetables, in grains, in fruits, in all products including animal products like butter, ghee, milk and so on. Invariably, in places where intensive agriculture is carried out we find an excessive quantity of pesticides. For instance, cauliflower or cabbage or most other vegetables like Bhendi, Brinjals, Tomatoes often have two to three times higher level than the tolerance limit and in certain cases easily even 20 times more than the tolerance limit. The residue in milk has also been estimated in almost 95% of the samples which we could collect. We collected milk samples from different parts of Tamil Nadu, estimated for the content of DDT, BHC and heptochlor and similar other organo chlorine compounds and in about 95% of the samples the pesticides were there. Even the human milk samples contained pesticides above the tolerance limit. We collected milk samples from mothers in nursing homes in the first one week. The new born baby is consuming milk contaminated with pesticides be-

cause of the food cycle. We apply the pesticides in the soil or on the crop. Then, the straw or cake or other fodder crops are eaten by the animals and from the animals the milk comes to the human being or from the vegetable or grains it is coming to the human being and it is passed on again through the milk.

So this type of pesticide pollution through food is very common. Of course the atmosphere which we breathe, the air which we breathe is polluted with many chemicals including pesticides. The water is polluted. There is a place called Humayun Sahar very close to Andhra Pradesh Agricultural University which is very famous for grape wine cultivation. They apply chemicals like *carbofuran* in the soil for controlling nematodes or for controlling some of the sucking pests found on the shoot system. It is in a slope. The rain water as well as the irrigation water will dissolve the chemicals and chemicals are taken as an under current polluting the well waters for about 3 - 4 kms downstream. And when we drink water from such wells we get dermatitis we get several nervous impairments due to the polluted water. Watermelon is very common in summer months. It is full of pesticides. Grapes, fruits are dipped in pesticides, so the chemical residues are very great in most of these. That is why we have to go for non conventional methods.

There is not only the residual problem - the insects have also developed resistance to many pesticides. *Heliothis* popularly called as American bollworm is a polyphagous pest which feeds on more than 200 types of plants. It has developed seven hundred fold resistance in our country to synthetic pyrethroids, to organochlorines to organophosphates and virtually we are left with very little choice to tackle this pest. Because of the increase use of pesticides in the cotton ecosystem, particularly in the Guntur and Prakasam districts of A.P., the pest has developed very heavy resistance. The moths are capable of flying very long distances. They are taken by wind also to long distances. In that process the progeny which is found in some other ecosystem is also not amenable for chemical control. Recently we have come across another problem. We try to tackle certain pests. Mostly the caterpillar or worms. We may solve them but we get side effects due to resurgence or secondary outbreak of some secondary pests like aphids, leaf hoppers, mites which are also vectors of many diseases like viruses and mycoplasma like organisms. So we are not able to solve the problem in one phase. Each time we create more and more problems. Because of this only there is a need for using chemical insecticides more judicially. They are costly, they are not safe and they have several side effects including the interference with the human system and that is the reason why we have to go for more and more biological control.

Biological control, I would define as, using living organisms or their products - it may be a parasite, it may be a predator, it may be a virus or bacterium, fungus killing the insect or other invertebrate and not only that even plant products, the plant derivatives. Thus even substances like pheromones which attract the insects or allomones or Kairomones, whatever natural products or natural organisms that can be used to minimize the damage by pest, we can classify them under biological control. It is again not only for pest, but for disease as well as we have several soil borne fungal diseases causing root rots or wilt. If whole plant dries up there are certain antagonists which can be inoculated in the soil which will kill the pathogenic plant disease-causing organism. Similarly there are several biological control agents which can be used against weeds. Remember we had this *Opuntia*, which we used to call Sapathi Kalli. It used to be found in large numbers earlier and due to the introduction of beetle, as well as caterpillars these weeds were completely destroyed. There are many such cases. The *Lantana* which is a serious weed in plantations was controlled by weed killer. Right now the Indian Institute of Horticultural Research scientists have developed methods to control water hycaninth. *Salvenia* is a serious aquatic weed in the west coast affecting the navigation and affecting irrigation channels. It covers the whole water surface, tanks, rivers and streams. For controlling them there are some weevils and some beetle which can be cultured and released. They are specific to weeds and do not affect the crops. So tremendous progress has been made in the field of biological control.

Only thing is we need to have agencies which can mass produce these agents and supply to the farmers at reasonable costs at appropriate times when they are needed because most of these biological agents are stage specific. My friend Mr.Solayappan who is here has done lot of work on egg parasites, *Tricogramma* in the control of sugarcane internode borers which is a very severe pest throughout the country. Unless you are able to release parasites when the eggs of pests are there it is not effective. Similarly we have got in the case of cotton or vegetables for controlling many borers egg larval parasites. Again we have to introduce them at the egg stage of the pests. Eggs are not killed but only the larve are killed. You have to monitor the incidence of the adults by pheromone traps, by light traps, by insitu counts and then release the parasites according to the need. Not only timing is important but dosage, the rate at which the natural enemy has to be released is important. Fortunately in Tamil Nadu we have 42 parasite breeding centers in the two departments of agriculture and oil seeds. They are working on biological control of the coconut pests, sugarcane pests, and few other crops. Now we would like to bring all these parasite breeding centers under one umbrella so that we will be able

to culture not only parasites and predators for these two important crops namely sugarcane and coconut but for all the other crops grown in that particular area. They should also be able to culture the insect pathogens like viruses, fungi, bacteria and so on. Then the weed killers - they are antagonistic organisms to control the plant disease causing organisms.

I think we are moving in that direction and Tamil Nadu is the forerunner in biological control movement. Even in 30's and 40's several parasites and predators were introduced only in this part of the country and from here they were taken to other parts of the country. In the whole of the country, the Government of India has only 11 biological control labs as against 42 in Tamil Nadu alone, and many states do not have even one. Kerala and Karnataka have about half dozen laboratories but we can strengthen this movement in Tamil Nadu because we have much more technology for solving almost all major pest and disease problems. I think in course of time we will have not only the Governmental agencies but also the private agencies. There is one biological control laboratory in Bangalore which is the only one under the commercial insectory sector. They are producing lot of parasites, predators for different crops. I think the Government will have to encourage private entrepreuneurs to come forward to mass-produce the biological control agents and supply to the farmers at cheap cost. I would like to mention here that in countries like U.S there are large number of commercial insectories which produce, which go and release and they take up the responsibility of pest management in thousands of acres under contract system. I think that even the unemployed graduates can take up to this venture. The Tamil Nadu Agricultural University would be willing to give training to them and we will be willing to give them the nucleus culture and continuous support for quality control, and for technical support. We will certainly be able to help B.Sc. Zoology, B.Sc. Chemistry or B.Sc. Agriculture students who can take up to this self employment opportunities. There is tremendous scope. In U.S you can see many common advertisements in newspapers about sale of nymphs of dragon flies or damsel flies. They will be given in a polythene bag with water and you can put it in your overhead tank or Septic tank. They will breed there. They will kill all mosquito larvae. They do not resort to applying DDT. DDT is banned in these countries for several decades now. Unfortunately only in our country it is still being used for public health and from public health sector it comes to the agriculture sector, poiluting the entire environment. So there is a possibility of using the dragon flies which are common in our wet land system. They are easy to culture, can be supplied to town people and cities for mosquito control.

So biological control movements have to take strong roots, not only for agriculture but also for public health aspects. I am sure that our country will be able to contribute in this area in the years to come and for this the scientists and teachers in the universities have been toiling their best to develop the technology and we should be able to develop useful strategies in this seminar, as to what the universities should do, what the Government Departments should do, and what the voluntary organizations should do and what the farmers and general public should do. If we can create that type of policy, ultimately, the government, through its supporting systems can promote the concept of biological control in our country. With the actual participation of the voluntary agencies we will be able to organize a series of training programmes in villages and ultimately we will be able to educate the farmers and general public about the hazards of existing methods of chemical control and the benefits of the non polluting biological control. I think we should develop strategies for organizing series of training programmes in which again TNAU will be a willing partner. I have great pleasure in associating myself with this programme and again I have immense pleasure in inaugurating this workshop. Thank you very much.

S. Jayaraj

THE WAY TO SURVIVAL*

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We are living in a world, where human beings have adopted a life style which in the name of progress and development takes us towards death and destruction. This process started when the Industrial Revolution in Europe made two basic changes in human thinking about nature and man. Nature was regarded as a commodity and society only the society of human beings. Thus, the objective of development became the exploitation of nature for the benefit of human beings alone, ignoring other beings. The direction of science and technology was influenced by this thinking. Scientific research unfolded the mysteries of the physical world and human greed developed a technology to exploit nature. All the hidden treasures of nature were plundered in no time with the help of technology. This is how the prosperity, of which modern civilization boasts, has been achieved.

We had been blessed with four renewable resources-- the grasslands, forests, crop lands and oceans-- over which all life on this planet subsisted. It were not only the non-renewable resources like metals and minerals, which became the victims of human greed, but these renewable resources also became non-renewable due to over-exploitation. The whole concept of green revolution, applying the industrial practices, of industry to agriculture, is the living example of the exploitation of croplands. Chemical fertilizers, became the main components in agricultural production. The application of chemical fertilizers ignores this truth that soil is not a dead matter, but a community of living things - bacteria, earthworms etc are the members of this community. In the traditional method of organic farming, where cow dung, green manuring, and leaf-fertilizers were used, this community prospered. But when these were replaced with chemical fertilizers the living elements of the soil became extinct.

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* Key note address

Today our farms have become addicts. Nothing can be produced till the farmer satisfies the farm's devilish demand for chemical fertilizers. The analogy of the human body applies to the soils. When the human body loses strength, it cannot resist the disease. Similarly the soils weakened by the chemical fertilizers are unable to resist the attack of pests. Thus came the chemical pesticides. When chemical pesticides are applied, other living beings, which in a natural system control the pests and maintain the ecological balance, fall prey of these. The extinction of frogs,snakes and owls is a glaring example of this. Everybody is familiar with the role of frogs and snakes in controlling the pests, but very few knew about owl. Dada Salim Ali once told me, "Do you know how useful the owl is to us" I said, "Dada! you in your blind love for all birds eulogise even nasty birds like owl". Dada replied back, "My conclusions are based upon the scientific studies, which I conduct watching the behaviour of this bird. An owl preys upon at least three rodents in a night. A pair of rodents reproduces seven hundred in a year. It is said that five rodents destroy as much food as is enough to feed a person. I realised why our ancestors honoured rodent by making Lakshmi (the goddess of wealth) ride on it.

I remember when Community Development Projects, borrowed from America, were first launched in the early fifties, zinc-phospate was distributed to kill the rats. The rats died, but with this the cats also disappeared and vultures the nature's scavengers also died. But do the pesticides actually protect the crops? I leave this to the scientists, but I have read a recent report about farmers launching a stir in Ganga Nagar district of Rajasthan. This area is also the centre of Green Revolution, as it was the first beneficiary of Rajasthan Canal. Crops worth millions were destroyed during current Kharif Season due to the application of pesticides. The pesticides manufactured by factories in Fatehabad and Sirsa (Haryana), which were supplied to these farmers, were found harmful and have now been banned. The farmers are now demanding compensation for the loss of crops.

The disastrous effects of pesticides on human health are now well-known. In west, where people have become very conscious about the poison in food, a number of pesticides have been banned, but these are being popularized in poor countries. There 'Natural Food Stores' which supply food including fruits and vegetables by organic farming, are becoming so popular and important that I have seen these along with medical stores. The demand for these is so high that a few years ago I met a Swiss farmer in Berne, whose farm products were sold within few minutes. City people, with their shopping bags stood waiting for the arrival of his horse

cart. M.Fukuoka, the father of natural farming system, who deserves to be called as Krishi Gandhi, told about the high demand of Oranges grown in his natural farm.

The main causes of the quick expansion of unnatural farming system have been:

(1) Human greed to have more consumer goods and

(2) Population explosion.

Though in poor countries, Green Revolution is eulogised by saying that millions would have died of hunger without it, but in affluent societies where over production has become an economic problem there is no justification for it. The main cause of adopting the exploitative farming system is to achive the affluence which has become the symbol of progress. Agriculture was culture, (The meaning of culture is sublimation of nature for the achievement of peace, happiness and fulfillment for all creatures), but now it has become a commercial venture; otherwise the sugar-cane farmers of western U.P. and Terai region and wheat farmers of Punjab, and Harayana would not have switched over to Eucalyptus farming; which has now proved economically disastrous. The main force behind unnatural farming is the industrial interest. Farmers to-day have become solely dependent on outside inputs and thus most of their earnings goes to the industrialists. They have become the bonded labourers of the industries and bankers. This was first realized by the farmers in Mexico, where they could not bear the burden of bank loans and were uprooted from the soil. Now one fourth of the population of Mexico is concentrated in Mexico city. Farmers in many South-East Asian countries, specially in Philippines are realizing that their earnings are going to fertilizer and pesticide industries and the banks. The symptoms of this are visible in India to-day. The farmers demand to write off the loans and for more subsidies is the clear indication to this. No government shall be able to solve this problem. There is no wonder, if more and more distressing reports of farmers' suicide like those from cotton farmers of Andhra committing suicides come.

The other aspect of this problem is more frightening. Our farming system has become more and more water-consuming. The World-wide scarcity of water is an established fact. According to World Watch Institute studies, per capital availability of water by the end of this century will be 24% less as compared to 1983. India is on the margin. How quickly the availability of water is decreasing is clear from the figures given by Madhav Chitley, Chairman of the water commission. Per capital availability of water in India in 1901 was 9404 cubic meters. It

came down to 6,972 cubic meters, i.e., approximately 26 per cent less in 1941, but 3,243 cubic meters in 1981, i.e., 65 percent less. Even if the rate of decrease remains static per capital availability in 2001 will be 14 percent as compared to 1901.•

It is not only for irrigation that un-natural farming needs more and more water to the extent that 150 lives are lost in an average every year in Tanjore district, the bread basket of Tamil Nadu, on account of water disputes; but fertilizer plants consume excessive water. The plant of Gujarat State fertilizer corporation, the refinery adjacent to it and the plant of Indian Petro Chemicals Ltd., consume every day 350 lacs gallons of water, which means 117 lac pots of drinking water every day considering average consumption of even 10 pots a day per family, this water can meet the needs of 11.70 rural families.

Human kind to day is in search of viable alternatives, because the existing exploitative system which is the outcome of modern man's aggressive behaviour towards nature, has threatened the survival of all life over this planet.. Scientists have predicted that by the end of this century 15 million plants and other species will become extinct. The United Nations Commission on environment and development in its report 'Our Common Future' has summed up this as: "Settled agriculture, the diversion of water courses, the extraction of minerals, the emission of heat and noxious gases, into the atmosphere, Commercial forests, and genetic manipulation are all examples of human intervention in natural systems during the course of development. Until recently such interventions were small in scale and their impact limited. Todays' interventions are more drastic in scale and impact, and more threatening to life support systems both locally and globally. This need not happen. At a minimum, sustainable development must not endanger the natural systems that support life on earth, the atmosphere, the waters, the soils and the living beings,..... Maximum yield must be defined after taking into account system-wide effects of exploitation". The report suggests that, "future increase in productivity in both developed and developing countries should be based upon the better controlled application of water and agro-chemicals as well as more extensive use of organic manures and non chemical means of pest control.

But biased science, which is a tool in the hands of short-sighted politicians-impatient to show miracles during their short tenure-and greedy industrialists will not change its direction easily. We need a revolutionary change in our thoughts and action. I view this meeting on "Biological Methods of Pest Control" in this context. There is darkness all around, but amidst this darkness the small organisation

of "Patriotic and People-Oriented Science and Technology Foundation", is a ray of hope to travellers like me who are in search of alternatives to the existing system. We are living in a world, where 400,000 (lacs) scientists are busy in war-research and Rs.210 millions per minute are spent on machines for killing.This is only about those who are engaged in efforts for direct killing. If we add to it all those, who are busy in exploitative research, the number will rise to millions. so the question arises, will the small organisations like P.P.S.T. and isolated researchers like Vijayalakshmi and others, be able to divert the flow from death to life. And my reply is 'Yes'! I say this with full confidence, because there is the historical evidence behind my conviction.

All through the long course of human history, there has been creative personalities like Buddha and Christ, Lenin and Gandhi, who were responsible in bringing about change. In modern India, the process of change had started with renaissance which was pioneered by Raja Ram Mohan Roy, nurtured by great personalities like Rabindranath Tagore, Jagadish Chandra Basu and finally popularized by Mahatma Gandhi; but we were disillusioned by the glitter of materialistic civilization and the march of renaissance temporarily came to a halt. With the world-wide realization of the destructive aspect of materialistic civilization, a suitable atmosphere for the advancement of renaissance has been created. Local dedicated groups of humanitarian scientists, social activists and compassionate literary men, artists and journalists will be the pioneers of change. They are the symbols of Gyan (knowledge-scientists), Karma (action-social activists) and Bhakti (devotion-literary men) and the message of our philosophy is that the success of Yajyan (noble action) lies in the combination of Gyan, Karma and Bhakti.

We should not wait for big names and big organisations. I am reminded of a poem of gurudev Rabindranath Tagore: once Surya (Sun-God) said, "I wish to take rest. Is there anybody to take over my job?" everybody was afraid, "how can we replace such powerful personality like sun-God". A small lamp (deepak) came forward saying, "Sun-God! you take rest. I will continue burning in your absence". This small light became the ray of hope to those groping in the dark and a source of inspiration to those busy in searching out a new path. I have been wandering for several years in the remote corners of this country and in many parts of the world. I have met several such small lamps, who have been spreading light all around them. There are people like Mashanbu Fukuoka, which are now well-known, but most of these are less known. Since they are swimming against the tide, they are

facing ridicule, neglect, isolation and insult. I have a vast treasure of these and this is what I have with me to offer as a key note address to this seminar.

But I can assure you that, though a creative minority, you are the pioneers of a new era of peace, happiness and fulfillment to all living beings over this planet. Your course of action has been aptly put by the great historian Arnold Toynbee in these words.

"The growth of a civilization lies in the hands of a creative minority. The elite must have the power not only to cope successfully with the challenges to which their society is exposed, but also to carry along with them the majority of uncreative people". We are marching from 'Death to Life' and our slogan is Yes to Life, No to Death.

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REVIVING OUR TRADITION
(Extracts of talk on release of Souvenir)

N. Haribhaskar,
Secretary, Department of Agriculture, Government of Tamilnadu

I am deeply honoured that I have been given a chance to address you. There are two reasons for which I am particularly obligated to the PPST Foundation. I had looked forward to meet Mr. Sunderlal Bahuguna. He has become a byword. His name is known all over India and I doubt very much if there is anyone who reads the newspaper has not heard of him. He has almost become historical; so that particular desire of mine has been fulfilled today. The second was that the PPST for the first time came forward to focus attention on biological control. I have been very fond of this theme. Somehow we have not focussed attention on this. So when it was suggested by the PPST people like Dr. Vijayalakshmi and others who have come and met me I was very happy to say yes and agreed to come to this function. Mr. Sunderlal Bahuguna has already told you in an exhaustive and illuminating lecture which concluded just now as to what is happening in India and also elsewhere in the world, in the field of agriculture. We know that many of us have cast off our old ideas in the name of modernity. But even in the field of agriculture you will find that the old system of self help which many of our farmers used to be doing in older days is no longer there. I would like to illustrate this by the *Kudimaramathu* system which they used to follow. In olden days during summer times the farmer himself used to come forward to clean up the channels and see that they are ready for the irrigation period. Today no farmer comes forward. All of them are dependent on the Government. In fact I would say this is the unnatural farmer - not the natural farmer that was being referred to by Mr. Sunderlal Bahuguna. So what is happening today is all our farmers are fully dependent on outside help, Government help basically, and to a large extent what is said of the farmer becoming more and more a creature of loans is true and he is actually living from loan to loan. We have to see that it is no longer there and especially in the field of pesticides.

We are spending a large amount of money especially on the farmer. Whether we take the oil seeds, rice, groundnut or even cotton, pesticide expenditure is very

very heavy. Fortunately, we in Tamil Nadu, have an Agricultural University which has been doing an extremely excellent job in this field. They are trying to bring in a system of Integrated Pest Control which has been commended all over India, even by the ICAR and Government of India. And last year because of this system we have saved more than a crore rupees. And, to that extent, we are indebted to the scientists of the Agricultural University. As Dr. Jayaraj just mentioned here a while ago the Department of Agriculture has also not been very idle. Nearly 46 biological control laboratories have been established in the state and many of them are giving the farmers biological control agents at a highly subsidized rate.

You must be knowing that, by our own activity of use of pesticides, several useful insects like spiders, beetles etc are destroyed with the result that they bring in bigger headaches than what we intended. In the West they sell even pesticide-free vegetables. Mr. Sunderlal Bahuguna mentioned about what happened in US. But then whatever happens in the West we cannot take it as such. Because in the US for example land is not a limited commodity. It may be of interest to you to know that in 1818 50% of the people of US were dependent on land. According to 1970 census less than 5% are dependent on land. So that much of the land is available there and what can be done in the US may not be possible for us to do. But then it is essential that our scientists or government or others take up schemes which will relieve the agriculturists, the farmers from this tight grip of pesticides, and even to a large extent, fertilizers have on them. The pollution is taking place because of these things, something about which we did not even think of. As Dr. Jayaraj has said in many places DDT has been banned. But we still have this in our country. The residual harm is something that we cannot even think of. A little while ago he was telling me that in Trichy when they analysed the canal water how they found it full of magnesium salts, which in turn effected abortion, cancer and low milk yield in the cattle, and human beings who drink this milk will also be affected. This is the situation in India today. We are not very much bothered about what is happening and it is high time we know and begin to think of it. I am really grateful that the PPST has, today, has tried to focus attention on this particular aspect. I am glad that I was able to come here and I am obliged to them for having given me this opportunity to release the Souvenir.

INTRODUCTORY REMARKS ON THE CONTENT AND BACKDROP OF THE CONFERENCE

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I am really overwhelmed by the speech of Bahugunaji and the kind of points that Prof. Jayaraj brought out in his inaugural address. So there is nothing much, by way of either the theme of this conference, or the global context, that I can place before you. All that I can say is something about ourselves, the PPST Foundation, as to what we are upto or what we think we are upto and why we are holding this conference.

We are an All India network of scientists, technologists and social scientists and activists. We have been active for the past 8-9 years though we are a registered body, a Trust, for the past 2-3 years. We bring out a journal PPST Bulletin, which is a quarterly devoted to the analysis of the Indian Science and Technology scene today with a view to revitalize both Indian Science and Indian Society, relink Science and Society in India and make both of them functional and dynamic.

We have broadly three themes in our activity. One is, we want to indigenise the modern sector in India, make it functional. Much of what we call modern is outdated-like our University Laws which date to 1875 and 1878, or our Forest Laws or most of our other structures and institutions which are just not functioning. Anything we produce we do not value. Prof. Jayaraj who runs one of the major Bio-control Science journals should know that most of Indian scientists do not patronize Indian Scientific journals inspite of the fact that we have several research laboratories and India ranks 8th by way of scientific research output.

The modern sector in India will have to acquire an Indian character. It has to acquire a certain Swadeshi spirit which was a focal theme of our independence movement. At the same time as concerns the basic needs of our people we will have to, in some way, build upon our own indigenous knowledge base, our indigenous technologies, our people's wisdom. Only that way we can at least hope to bring back millions of ordinary Indians back to the "mainstream". What do we

mean by bringing our people back to the mainstream? Not as unskilled labourers in plants about which they know nothing, but as really creative innovative human beings operating on their own on the basis of theories and ideas that, at least, they can comprehend and play around with and work in an idiom that makes sense to them. Much of our health sector, agricultural sector, cattle breeding, animal husbandry, diarying or even metallurgy can acquire life once again if they can be rooted in the Indian knowledge systems and Indian practices. PPST firmly believes that there is a vast knowledge base in India which we scientists have just not tapped - just as we have not tapped the indigenous modes of social organisation, or for that matter the potential of our own languages.

Another issue which has been focussed upon by PPST is the urgent need for a fundamental restructuring of our polity, our political, economic ideologies, our social organisations to be more in tune with the Indian ethos, the way in which Indian civilization worked. For instance, nowadays, 20 years after green revolution, we have started talking of agro-climatic zones. If any of you go back and read the vast literature on the 'Nadus' in Tamil Nadu (Prof. Subbarayulu of Thanjavur Tamil University wrote over 20 years ago, on the 108 Nadus in Chola Mandal) each of them was an agro-climatic zone, about which we have not much information today. I would request the Vice Chancellor really to get back to the indigenous knowledge of agriculture, to the indigenous knowledge of agro-climatic zones as a focal point around which agricultural planning can be done in our country.

Now let me talk a little bit on the conference itself, what has been the PPST's understanding of the development of Indian Agriculture in the last century. The environmental - ecological issues involved have been very clearly highlighted by our Vice-Chancellor so I do not have to say anything more about the hazardous effects of pesticides. Only, I have to mention that pesticides are harmful right from the birth point as the Bhopal tragedy showed us 2-3 years ago. But the main issue around which I think the problem all the time revolves is a certain dichotomy that is usually perceived between development and ecological sustainability. That the main argument for employing chemical fertilizers and pesticides irrespective of whatever all the environmentalists may say, has been the claim, that productivity of chemical agriculture is high. And this is where I think we have to take a fresh look at the data. We should not be carried away by slogans of one type or the other. This is for our scientists to really sort out in the interests of our agriculture. I want to present some data, based on the articles published in the PPST Bulletin.

TABLE - 1

The Deccelaration in the rates of growth in Indian Agriculture (in % per year)

Period	Aggr. Product.	Aggr. Yield	Yield per acre of Food Grains Wheat	Rice	Jower	Maize	Gram
1951-65(Pre GR)	3.85	2.01	2.85	3.82	4.01	4.88	3.67
1968-82(Post GR)	3.07	1.85	3.36	2.41	2.48	1.67	0.25

Let us take a look at the rates of growth in Indian agriculture during the pre-Green revolution and the post-green revolution periods. These are presented above in percentage/year (Table 1). In the pre-green revolution phase in India, Indian agriculture did very well. It grew at a rate of 3.8%/year whereas our population grew at a rate of only 2.5%/year. But in the post-green revolution era, the rate is declining and showing further and further decline. But when we look at this aggregate from crop to crop, wheat has definitely shown an increase in yield from 2.9% to 3.4%/year. So green revolution has been a wheat revolution indeed! What

TABLE - 2

The Revolution in Inputs - Fertilizers Consumption

Year	Total Fert. Consump. (1000 tonnes)	Fert. Consump. per hectare (Kg/ha.)	Fert. import bill (Rs. in crores)
1951-52	66	0.6	5
1958-59	224	1.5	11
1967-68			599
1975-76	2894	16.9	
1981-82			717
1982-83	6388	37.0	
1984-85			1435

TABLE - 3
Pesticide Consumption

Year	1950-51	1966-67	1970-71	1980-81	1983-84
Total Tech. Grade Pesticides Consumed (1000 tonnes)	4	7	20	45	55

about yields of rice or other grains? Most of them have shown a tremendous decleration in the past 20 years.

But there has been a real revolution in terms of inputs (Table 2). The fertilizer consumption has gone up from about 66,000 tonnes to about 6 million tonnes. We are still undeveloped. We use 37 Kgs/hectare whereas Japan uses 400 Kgs/hectare and New Zealand or Netherlands is using 900 or 950 Kgs/hectare. About 50 years ago it was believed that civilization be measured by the amount of soap that people consume. Now it can be measured by the amount of fertilizers and pesticides we use. There was hardly any trace of pesticides in Indian environment; about 30 years ago we used 4000 tonnes/year. It has increased to 55,000 tonnes/year (Table 3). This is technical grade. The formulations will be about 3 times. So, I would say quite firmly that we took a totally wrong direction in 1985. Now we are talking of a Second Green Revolution. Before that we should acquire a better understanding of what we should do. All my figures are based upon government data. So maybe it is not accurate. Maybe the picture is different. We should perhaps have a major commission to look into this just as the National Commission for Agriculture, which was set up in the early 70's and which worked for 5 years and brought out 13 very important volumes. We should have such a commission re-investigating the Green Revolution and what has happened, so as to work out what should be our policy for the future, especially on dryland agriculture - the new green revolution that we are talking about.

In the context of this conference I would like to emphasise that India has to really build upon its own traditional system of Agriculture. But what do we know about our traditional systems of Agriculture? Of course our farmers still, to a large extent, are aware of soundness of their practices. But do our scientists know anything? Just as Bahugunaji requested our Vice Chancellor that there should be a section on

natural farming, I think every Agricultural University in India should have a major section studying the traditional agriculture of India. Do we not claim that we have a 5000 year old history of agriculture? But the only document that we find in most libraries (including the renowned libraries of ICAR) on our traditional agriculture, the only information that we seem to have are the reports of 1880's 1890's or the early 20th century. The latest data on the 1 lakh tanks in South India is as old as 1920. Take for instance our present day idea of *Kudimaramathu*. I should mention that PPST is doing a very major study of 1500-2000 villages in the Chenglepattu area based on data from our Tamil Nadu State Archives pertaining to a period 200 years ago. The kind of picture that emerges as regards the political economy of our villages is indeed of great significance. Each village had allotted about 4% of its gross produce as 'Irrigation fund'. So this was what was sustaining our *Kudimaramathu* - not any amount of exhortations or sermons to our people. If we want to revive the system we should understand the kind of economic arrangements and the community structure that prevailed in our villages, and which functions even today at a very subdued level.

After we comprehend our own sciences and their social support structures, if we come across any idea of technology that suits us, from anywhere in the World, we should be happy to take it. But what does not suit is, even if it be the most priced jewel that somebody else is proud of, we should not be bothered about. We should not be proud merely signing agreements, that so and so is giving this and so and so is giving that. Yesterday has been a day of signing agreements in this coutry with the visiting Soviet leaders. I do not think that our scientific community should take pride in signing agreements. In fact we should take pride in following our own ideals, learning from anything and everything that anyone else has done in this World, to the extent they suit us.

Traditional Agriculture

THE SCIENCE OF THE TRADITIONAL AGRICULTURE OF INDIA

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In the context of the search for alternatives to chemical pesticides, the term "Integrated Pest Management" (IPM) has become very important. IPM has been termed "a holistic approach aimed at minimizing pest impact while smultaneously maintaining the integrity of the ecosystems". However, even a cursory glance at the traditional knowledge on agriculture reveals that the traditional approach had achieved precisely this kind of equilibrium. Hence, it becomes instructive to take a look at the traditional agriculture of India, some aspects of its theory and practice, and its evolution in the last two centuries.

Here it is important to note that there has been no systematic effort in this country to document, study and understand what must be rightly termed as the traditional science of agriculture. There are several traditional texts on agriculture and horticulture which have occasionally caught the attention of some serious scholars here and there. However, we do not even have a complete bibliography of all the works on Indian agriculture available in all the Indian languages.

A whole lot of primary sources on agriculture are in manuscript form and even information regarding the extent and nature of this manuscript wealth is yet to be compiled for most Indian languages. An enormous amount of information on agriculture is available in the form of folk sayings and proverbs in many Indian languages. No systematic work seem to have been done in recent times in bringing this knowledge to light.

Since there has been no documentation and study of the traditional agriculture particularly its practice, the major available source of information of this practice unfortunately comes to us from the observations of Englishmen during the 18th and 19th centuries.

The Period of British Rule

Some of the important sources for details on the practice of Indian Agriculture in the 19th century are:

1) "Report on the Improvement of Indian Agriculture" by Dr.John Augustus Voelcker. Voelcker was the consulting chemist to the Royal Agricultural Society of England. He was deputed by the British Government to make an enquiry into Indian Agriculture and advise upon - (a) The improvement of Indian agriculture by "scientific" means (scientific here means the application of the then Western science of agriculture). (b) The improvement of Indian agriculture generally. The central aim of all such "improvement" of course, was an increase in the land revenue. Voelcker toured the country extensively from Dec. 1889 - Jan. 1891. His report was published in 1893.

2) "India in 1887" by R.Wallace, another British agricultural scientist who also toured the country extensively recorded in detail his observations of Indian agriculture.

3) "A text book on Indian agriculture" (Published in 1901) by J.Mollison of the Bombay Agricultural Department, who later became the first Inspector General of Agriculture in India.

The studies mentioned above give very detailed account of the knowledge and agricultural practices of India which was obtained at the end of 19th century. Cultivators' knowledge of soils; irrigation; manure; forest; grazing; livestock and dairying; agricultural implements; crops and culivation; including practices such as rotation of crops and mixed cropping, fallowing selection of seeds, storage of grains - all these have been described in great detail. (See PPST Bulletin, Vol.2, No.2, for details).

As regards the technical aspects of Indian agriculture, the British/European observers of 18th and 19th centuries were in no position to really appreciate, or even comment on them. Several of the indigenous Indian practices which were perfected centuries ago, such as the rotation of crops, the perfection of drill plough and sophisticated animal husbandry and breeding were relatively unknown in the 17th cenury Europe, and are in fact cited as the major advances achieved during the 18th century "agricultural revolution" in Europe. Thus the sophistication of Indian agriculture was considerably beyond the comprehension of the British administrators of the 18th and early 19th centuries. For example, Capt. Thomas. Hal-

cott, who was one of the earliest to take notice of the practice of drill husbandry in India, in 1797, frankly acknowledged that "Although it (i.e. drill husbandry) has been practised under the eyes of everybody in the Guntoor circar, no one that I mentioned (it) to (had) ever observed it before, nor did I observe it myself lately" [Dharampal, 1971].

The all-round excellence of Indian agriculture was perhaps first documented in detail by Alexander Walker in a report written around 1820 (Dharampal 1971). In 1832, while testifying before a committee of the British House of Commons, Dr.Wallick, the superintendent of the Royal Botanical Gardens in India, was asked, "whether Indian agriculture was susceptible of any great improvement?" His reply was: "..... for instance, we should hardly see any improvement in that branch of cultivation". [PPST Bulletin, Nov. 1982]

Very similar views were expressed by several authorities, all through, right into the second half of the 19th century. While hardly anything was known to the Britishers about Indian agriculture, it does seem strange that from around the middle of 19th century Briish administrators start declaring vociferously that Indian agriculture is unscientific, backward, primitive, etc. However, the studies mentioned earlier, which go into details of the indigenous agricultural practices, present an entirely diferent picture than what one would have imagined of an unscientfic, backward and primitive system of agriculture. For instance, in the abstract of his report, Voelcker summarizes the basic conclusion he arrived at, as a result of his investigaton, in the following terms:

"I explain that I do not share the opinions which have been expressed as to Indian agriculture being, as a whole, primitive and backward, but I believe that in many parts there is little or nothing that can be improved, whilst where agriculture is manifestly inferior, it is more generally the result of the absence of facilities which exist in the better districts, than from inherent bad systems of cultivation....." (Report on Improvement of Indian Agriculture).

The middle of 19th century was the period when British and European agriculture started taking a more "modern" and "scientific" turn, symbolized by the employment of chemical ferilizers, newer mass-produced implements and so on, and the further shifting of the knowledge of agriculture from the peasants and the landed classes to agricultural research institutes and colleges. As the Royal Commission on Agriculture in India declared in its report (1928): "The dependence of agricul-

ture on empirical methods was general even in the Western countries until towards the middle of the 19th century, when the application of chemistry to soils in 1840 and the establishment of the Rothamsted Research Station in 1843 were rapidly followed by the opening of the first agricultural college in England at Cirencester in 1845".

In the second half of 19th century, primarily due to the disastrous land revenue and other policies of the British, there was an enormous increase in the incidence of famines in India. Today, it is well-known that this increase was closely related to the great spurt in the export of foodgrains made possible by the introduction of railways (in 1850's) and the construction of the Suez Canal (in 1869). The official explanation of the rise in the incidence of famines, obviously had to lay the blame elsewhere. And, what could be a better explanation for the famines than the simple "fact" that Indian agriculture was unscientific, backward, primitive, etc.?

Today 40 years after independence, it is indeed distressing that many myths continue to persist about the "backward" state of traditional Indian agriculture. One of the most pernicious of such myths has been the claim that the traditional agriculture had poor yields. However, all available data point to the contrary.

Agricultural productivity

The wheat productivity in Britain in the 17th century was 8 Bushels/acre. After the so-called agricultural revolution in the 18th century in Britain when the drill plough, rotation of crops and selective breeding of cattle, were introduced, Britain became the European leader in agriculture. As a result of these developments, in 1850's the wheat productivity in Britain was 20 Bushels/acre.

Data from the Allahabad area in 1903 indicates that the wheat productivity there was 56 Bushels/acre. per crop. As Indian agriculture had two crops per year, the total wheat productivity per year was 112 Bushels/acre.

Data from the Chengalpattu area (of Tamil Nadu) indicates that in the 1780's the paddy producitivity was more than 2,500 lbs/acre. Compared to this, in 1960 the productivity was only 1,680 lbs/acre. Similar data exists for North Arcot, South Arcot, Tanjore, Coimbatore districts of Tamil Nadu also, for the late 18th-early 19th century (Ratnam, 1966).

Cotton yield on dry fields of Coimbatore was 425 lbs/acre in early 19th century. During 1909-13, the average yield of cotton in USA was only 187.8 lbs/acre (Tapan Raychaudhuri, 1984).

Voelcker noted in his "report" that the wheat yield in India in the late 1880's was 15-25 bushels/acre on manured and irrigated lands. At this point of time the average yield in UK was 28-30 Bushels/acre; France 17 Bushels/acre and Germany 18 Bushels/acre.

It is only by the 1880's that the European yields start to catch up with the Indian yields. After this point European yields start to grow with the growth of "scientific cultivation" and Indian yields begin to fall, for reasons that have nothing to do with the Indian science of agriculture.

It must be remembered that: 1) Indian soils were capable of producing two crops per year as compared to Europe and USA which had only one crop annually. 2) By the 1880's India had already gone through a century of British rule, during which time the infrastructure for agriculture, such as traditional irrigation works and village forests, had been ruined due to neglect by the state. In addition, the village communities had broken up under the assault of extremely high land revenues, often more than 50% of the gross produce and the introduction of private property in agriculture. One other important factor was the deprivation of lands with respect to traditional manures. Cowdung was increasingly being used as fuel, starving the lands of manure, since the British state took away village forests and prevented the farmers from collecting their firewood from their own forests.

As Voelcker in his "Report" stated in 1893, the deficiency of inputs such as manure and irrigation water, was responsible for the fall in productivity levels in India. He pointed out that if these deficiencies were made up, Indian agriculture could regain its old levels of high productivity.

So despite a century of neglect and destruction under British rule, at the end of the 19th century, yield of Indian agriculture was still comparable to the best in the rest of the world. Despite all this evidence, however, Indian historians continue to perpetuate old myths regarding traditional Indian agriculture. For instance, a well-known historian after surveying the yield data given above, recently wrote "It is worth noting that despite the technological deficiency ..... and the fact that the Hindus did not have the advantage of scientific agriculture, the net figures (of

yields) are comparable". (Tapan Ray Chaudhuri, 1984). It is really amazing that instead of examining the practice of Indian agriculture and its theoretical basis to see how such high yields are possible, one takes a pre-conceived position that Indian agriculture had no scientific basis.

Agriculture As A Way Of Life In India

Before the British conquest, agriculture in India was a traditional way of life. It was no mere economic activity. It was the basic life-activity of most of the people of the autonomous Indian village. An early British observer of Indian agriculture, Col. Alexander Walker, noted the following about agriculture in Malabar in 1820 - "In Malabar, the knowledge of Husbandry (agriculture) seems as ancient as their History. It is the favourite employment of the inhabitants. It is endeared to them by their mode of life, and the property which they possess in the soil. It is a theme for their writers, it is a subject on which they delight to converse and with which all ranks profess to be acquainted" — (Dharampal, 1971).

The independence of traditional agriculture from external political or economic control was achieved through a social organization that left the village largely autonomous. The obligation of the village to the external political authority was limited to the payment of small proportion of the produce as revenue - which may have been as small as 5 per cent. (Alvarez, 1979). Having met this obligation the village was free to organise its own political and economic affairs.

Within the relatively autonomous village, the cultivator was relatively independent. According to recent estimates, the cultivator paid perhaps 25 percent of his produce towards various heads of revenue. A large part of this 25 per cent however, went towards financing economic activities of the village. This share of the produce was in fact, often paid by the village community directly to the individuals or institutions responsible for the above mentioned activities. Important allocations were made towards maintenance of infrastructure related to agriculture such as the irrigation tank or Ery and Channels (often more than 4% of gross produce); village forest and functionaries who took care of these facilities. It is interesting to note that even today, in Tamil Nadu, much of the irrigation management under Erys is supported by means of such traditional allocations. it is estimated that in the early British period, there must have been at least one lakh functional irrigation tanks or Erys, of all sizes, in South India. The wetlands under these Erys showed a relatively high level of productivity (as the Madras Presidency data show).

Village forests were carefully maintained. Each village seems to have used the village forests for all its needs - firewood, fodder, fertilizers and manure. Forestry and agriculture had a very close interaction (It must be noted that of late the term "agro-forestry" to indicate tree/forest growing to complement agriculture has now become quite fashionable). Besides agricultural lands each village had allocated a part of the lands towards grazing and kept another portion of the lands deliberately as fallow - which would be brought into cultivation every now and then. It is this fallow land that came to be called "waste land" under British rule - since to the British administrators any land which did not contribute revenue by growing crops on it was only a waste. It is only recently that the basis of such fallowing has come to be generally understood and appreciated by Modern scientists.

Classical textual knowledge

This is the social background and context for the development of the science of agriculture or Krsi sastra as described in the texts related to agriculture. The basic goals and world view of Krsi sastra can be best summarised with the help of a quotation from Charaka Samhita, the Ayurvedic text: "The basic aim of the concepts and fundamental principles of all the sciences is to establish happiness in all living beings. But a correct and thorough knowledge of the basic principles of the universe and the (human) body leads to the correct path to happiness, while deceptive knowledge leads to the wrong path". (Charaka; Sutrasthana, ch. su 29/35).In contrast to such a world view, the modern/western view is purely utilitarian - with humanbeings at the centre/apex of creation.

The classical texts may set out broad general principles as well as their application in a given context, say a particular region of the country. The fact that it is the particularity of the context that is the overriding consideration and the textual principles are to be considered as guidelines and not applied in a mechanical manner is driven home in many of the traditional Indian scientific texts themselves.

Incidentally, one very important feature of traditional Indian science and technology is that its knowledge, theories and principles are not meant to be reposed in a small number of experts, institutions or texts, but are created and shared on a wide scale, even by the ordinary folk who are the day to day practitioners of the arts and sciences. In the Indian tradition, as opposed to the modern Western view, a sharp, qualitative difference betwen the experts and the folk-practitioners (such as farmers) does not seem to exist. The "folk" practitioners are also equally the innovators in the frontiers of the science of agriculture and the theories and technical

categories belong to their domain as well. The expert or specialist seems to play the role of systematizing the corpus of knowledge. Thus there is no looking down upon the common folk or the lay practitioners. On the contrary the scientific texts themselves assert repeatedly that it is in the concrete particulars and in their use in a real situation that the truth of the Sastras ultimately reside.

Hence in agriculture too, there was always a close interaction between the scholar or expert and the practitioner or the farmer. The textual material seems to be a compilation and systematiziation of the actual practice of agriculture. The link between the two, the text and practice is through proverbs in all Indian languages which express the folk wisdom and knowledge and seem to contain the same information as the classical texts. Hence these proverbs are as much a collection of scientific information as the texts themselves.

In the following section is presented a brief summary of the contents of some of the texts on agriculture. However, this is only a sketchy summary and this subject certainly needs a great deal of scholarly attention to unearth all the wealth of scientific information contained therein. Further, it must be remembered that most of the texts on agriculture are only in manuscript form still and have not even come to be published in print.

Vedic Texts

A great deal of attention is paid to agriculture; implements; cattle and other animals; rains; harvests etc. in the Vedas, particularly Rig.Veda and Atharva Veda. Agriculture was considered a noble occupation (the vedic word to denote agriculture is Krsi and the produce is called Sasya) Agricultural implements mentioned include the plough (several types). Oxen in teams of 6, 8 or 12 were used in ploughing and repeated ploughing was used. Cowdung (Sakrt) was used as manure and dried cowdung (Karisa) was considered superior. Harvesting was done with a sickle.

Agriculture was considered as an act of reproduction in much the same way as human procreation, (as the Atharva Veda says): "Scatter the seeds in the prepared ground (Yoni)". This statement, by analogy, indicates that already a sophisticated understanding of agriculture had emerged. (This has implications in the development of the theory of agriculture).

Most importantly, vedic-age farmers knew how to maintain soil fertility by means of crop rotation or changing crops from season to season. Taittiriya Samhita mentions rice in summer and pulses in winter in the same field. Two harvests a year were gathered. The cow was venerated and equated to mother earth.

From vedic literature it seems to be clear that the cultivator had knowledge of fertility of the soil; selection and treatment of seeds; seasons of growing and harvesting; crop rotation and other cultural practices; manuring etc. Irrigation by channels and water-wheels (Asmachakra) were known. (Subbarayappa et al. 1971).

Later Texts On Agriculture

Krsi Parasara: ***(G.P.Majumdar & S.C.Banerji;*** **Asiatic Society 1960)**

This is probably the best-known text avilable and published. It is attributed to Parasara. Majumdar, in this edition places the work in 950-1100 AD. It is likely that this text describes Bengal or rice-producing North Indian areas with plenty of monsoon rainfall. Written in verse form, it opens with a eulogy of agriculture and rice. Then the science of meterology and rainfall in some detail:

"Since rainfall is the basis for all agriculture and all life, one must with effort learn all about rainfall".

Then description of 4 types of clouds and effect of each, followed by methods of forecasting annual rainfall. Then prediction of immediate rainfall thro' movement of ants, frogs etc. and then relation of movement of planets to rainfall/drought. Proper care of draught animals is strongly ordained. Number of bulls used is eight and never a single plough. Next, a festival of cows and preparation of manure (cowdung). Next the parts of a plough are described followed by ceremony for announcement of ploughing (Hala-Pasarana) and the appropriate, auspicious time for this. Seeds-collection, preservation and sowing are described in some detail, followed by transplantation; thinning out of plants, weeding, drawing of water from fields; preservation of water in the fields. Nala Ropana i.e., planting a kind of seed in one corner of the field to protect the crop; finally harvest and threshing ceremonies and the storing of paddy.

It is interesting to note that in an edition of Krsi Parasara published in 1971, the author has compared the material of this text with various proverbs (popular in the Gangetic basin) attributed to the legendary figures Ghaag and Bhaddari and has

shown that these proverbs reflect the same knowledge that is contained in Krsi Parasara, and complete it in a way, by providing greater and more graphic detail.

Two features are fairly striking: the contents are technical in nature giving a precise idea of paddy-technology in that part of the country; and all the activities are coordinated with the movement of plants and stars. These two aspects are said to be the same in their details, even today in Bengal and some parts of the North, as they are described in this text. In this sense, this work is something like a manual for paddy cultivation even today.

Theoretical basis of Indian agriculture: Comparison with modern (western) agriculture science

The botany part of agriculture or Krsi Sastra is derived from or shared with the science of VrksayurVeda.

The Atharva Veda's instruction regarding the preparation of the field (Yoni) and scattering of the seed reveals a fundamental feature of the Indian science of agriculture. The word commonly used (in Skt.) to describe an agricultural field is Ksetra - the same word may be taken to mean the human womb also. This implies that the preparation and maintenance of the fertility of the soil is of fundamental importance in Indian agriculture. Good crops are a result of a well-prepared and fertile field as well as well preserved and sturdy seeds. A poor crop could be seen as something that arises from a field which has lost its fertility and seeds which are weak. Healthy crops can be obtained only by maintaining or restoring the fertility to the soil and using good seeds and eliminating weak seeds. Hence it is that the importance of manuring, inter-cropping, mixed-planting, crop rotation, - all of which are designed to maintain if not improve soil fertility was fully realised in the Indian science of agriculture. Of course, the role of 'pests' or 'external' agents is well-understood but the primary consideration is given to the Ksetra or the soil.

Outbreaks of disease and pest attacks on plants would be viewed on the basis of the same principles as epidemics on human species are viewed.The basic understanding is that epidemic outbreaks occur due to imbalances in the eco-system. One of the major causes of such vitiation of the environment is human error leading to wrong intervention in natural processes. Such error is termed "Prajnaparadha" Other causes could even be prevalence of Adharma or wrong ways of living.

The main protection against outbreak of epidemics is to have a thorough knowledge of nature so as to avoid causing serious imbalances in the eco-system.

Still, when an epidemic does break out, the basic cause of the individual becoming affected is the imbalance in the individual's constitution. So at such times one needs to pay a great deal of attention to strengthening the individual's health in order to provide immunity against the disease. Hence in agriculture extra care is taken in the treatment of soils, and in providing protection through planting pest repellent plants etc.

In understanding the constitution of plants and their disease and treatment the basic theory is the same as that of Ayurveda - i.e. the Panchabhatika nature of plants (constitution is made up of the five Bhutas) and the theory of three doshas leading to the understanding of well-being and disease and treatment of disease.

Incidentally, here lies one of the major differences between the modern (western) and Indian approaches to disease and treatment. The Indian science understands disease in terms of the imbalance of Dosha of the individual (plant or human being) and sets about restoring the balance in order to cure the disease. (This restoration is brought about by supplying the appropriate nutrients to the plant through the soil). It also recognizes the effect of worms, insects and other pests on plants.*

However, in the Indian science, extermination of the external factors such as insect pests is not the primary objective of the treatment. As a contrast, modern/western science seems to place the stress only on the extermination of the external source. So the destructive use of chemical pesticides has become the mainstay of the modern/western approach to plant care. Such an approach which ultimately destroys the soil-fertility by killing all useful organic life would be unthinkable in the Indian science of agriculture.

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* Researchers have pointed out that pests known as plant mematodes are referred to in Upavana Vinoda (Section XIII stands 183 & 184) and the value of fumigatioon in combating nematodes. (Tiwari & Mitra, IJHS, Vol.8, Nos. 1 & 2; May & Nov. 1973).

On the other hand, in Krsi Sastra the emphasis from the beginning is to grow sturdy plants in a healthy soil by the proper selection of soils; appropriate selection of the plants/crops to be grown in any area; treatment of seeds before sowing; proper seasons for sowing; use of manures; proper watering and the use of nutritious liquid manures; and the maintenance of the health of plants and restoring imbalances in their constitution etc.

Pest Management - Traditional and Modern

Plant varieties were carefully chosen so as to be compatible with the local ecology. India is said to have had a couple of lakhs of paddy varieties alone. These traditional varieties were sturdy and relatively much less susceptible to pest attacks. Besides, soils were rich in microorganisms, earthworms and natural nutrients. Natural predators kept the harmful insects under control. And plants which repelled harmful insects were planted in the fields.

A study of the traditional science of agriculture is illuminating not only because it allows us to device ecologically safe methods of pest control or management. It emphasizes the fact that so-called pests are merely the consequence of a disturbance in the eco-system where the fine balance between plants - insects - soils - human beings - animals has been upset. It is only by once again reestablishing this balance that the "Pest" problem can find a true solution. In the interim period, one must of course, study and learn from the natural and biological methods of pest control used traditionally or rather, those features of traditional agriculture which kept harmful insect population under control. We must note that a complete documentation of all the traditional practices in pest management is yet to be done. Although several isolated attempts have managed to gather some information, we are yet to see a major, coordinated effort in.this direction.

The modern approach of integrated pest management has then much to learn from the current-day practitioners of traditional agriculture. Without such learning from the wisdom of our farmers, biological control with the single-minded objective of exterminating all "pests" can become yet another intervention into nature whose consequences we do not understand. The traditional approach has always emphasized restoring the equilibrium of the eco-system and not exterminating this or that "pest".

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TRADITIONAL PLANT PROTECTION METHODS IN TAMIL NADU

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Our farmers are very conscious of plant protection from ancient days. There are many ancient literatures on protection of crops, trees, etc. from pests and animals. Many ancient practices in the literature are documented in the book "Agriculture in ancient India" published by I.C.A.R. , New Delhi. "Vrksayurveda" deals with various aspects of plant life. In some ancient literatures certain "Manthras" and "Yagas" are recommended for protecting the crops from pests and evil eyes of the human beings. Thiruvalluvar in his great work "Thirukkural" says that manuring a crop is better than ploughing and plant protection is more important than the both. Even planting or sowing of the crops during certain days and "nakshatra", is prescribed as a remedial measure for saving the crops from pests. If the plants, which produce their economic products above the soil (cereals, millets, etc.) are planted or sown on the "upper days" (Tamil-Melnokkunal) it will be free from pest attack and will yield well. The plants, like tubers, peanut etc., that yield below the soil should be sown on "under days". (Tamil-Keelnokkunaal) to save the crops from pests and to obtain good yields. The days, on which "Parani, Karthikai, Ayilyam, Magam, Pooram, Visagam, Moolam, Pooradam and Poorattadhi stars rule, is called upper days and the days on which, Rogini, Thiruvathirai, Pooram, Uthram, Uthiradam, Thiruvonam, Avittam, Sathayam, and Uthirattadhi stars rule are called under days. Further the farmers were able to forewarn themselves about the out break of the pests from the direction of the winds. It is said that if the North Westerly wind flows in the morning of the day on which the star "Uthiradam" rules during "Adi" (July-August) month, there will be a heavy infestation of insects and worms. But these ancient knowledges is only documented and its adoption is not seen in the villages currently except certain astrological considerations. However, later developed indigenous knowledges which are specific to the situation and well within the economic means of the peasant and small farmers are found here and there. Even though some of the practices are documented, many more remains to be understood and documented.

The farmers adopt traditional, agronomical and bio methods to protect the crops from the insects and diseases

Agronomical Practices

Agronomical practices include time of sowing, ploughing, keeping the fields clean, burning, maintenance of proper moisture, intercropping, border cropping, crop sequences etc.

More importance is given to proper time of sowing. Many Tamil proverbs indicate the importance given to the time of the sowing. One proverb indicates that "If Rice is sown in "Avani" month, the crop will be affected by the Gall Midge". If sorghum is sown beyond June third week the crop will be affected by the shoot fly. Further the sorghum crop should be sown after heralding the whole village about sowing time. This indicates the importance of synchronised sowing, so that in the earheadstage, the earhead bug attach will be less in an unit area.

Ploughing the fields during summer after every receipt of rain not only conserve the moisture, but also controls the weed population. Wherever red hairy caterpillar is a menace in peanut crops, the land is ploughed in summer and the pupa of the insects are collected and destroyed and also the pupae are exposed to be eaten by the birds. Some times small trenches are dug around the groundnut fields and the insect spread is avoided. In small holdings the caterpillar is killed by the hand in the initial stage itself.

In rice fallows of Cauvery delta and other areas digging the field bunds and catching the rats during the summer is an age old practice. By such practice the rat damage to the young paddy crop is reduced during the next cropping season. The setting up of rat bows in rice fields during the crop season will further reduce the rat damage. This bow trap is one of the best plant protection gadgets invented in Bharat. The unknown village inventor has to be applauded since this gadget is simple in construction, very efficient and cheap.

Whenever mealy bug attack is found in rice crops, the place of attacks are demarcated and after the harvest is over the demarcated areas are burnt to arrest the recurring of the pest in the next season. Further *calotropis* leaves are applied to the field as green leaf manure to control this pest. Burning of the Sugarcane Trashes before the next ratoon crop is also aimed at killing the insects and pathogens.

Irrigation as a Plant Protection Measure

In the rice nurseries, for controlling thrips,the whole nursery is irrigated so as to submerge the whole plant for some time and the water is drained to wash away the insects. This practice helps the young seedling to recover from the attack of the thrips.

Frequent irrigation is provided to the sugarcane fields for controlling the termites. Constant submergence of rice fields at certain stages helps to control the weeds.

In clayey soils where summer ploughing is not possible,the field is wetted and the weed seeds are allowed to germinate. Then the field is ploughed and the weeds are incorporated into the soil. This is done before sowing or transplanting of rice crops. If a garden land is heavily infested with weeds, particularly with nut grass, the land is converted for two or three years into wetland and the rice is cultivated. Afterwards the field is turned into garden land.

Inter cropping and border cropping

"Pulichai" (*Hibiscus cannabinus*) seeds are sown inter mixed with rice in upland dry rice fields for controlling termite attack. Red variety is considered better than the green variety. An intercrop of onion and turmeric crop also prevents termite attack on turmeric rhizomes.

Planting castor as a border crop around chilly crop not only provides a microclimate for preventing flower droppings but also acts as a trap crop for *Prodenia*. Inter crop of castor in cotton also serves the same purpose. Cowpea is grown with peanut crop as an intercrop. The cow pea crop attracts the aphid and makes the peanut crop free from aphid attack.

Many crop sequences and mixed cropping are used as a method of reducing pest attack and the risk is avoided.

Microclimate as a plant protection measure

If brown plant hopper attack is found in the rice fields, the common practice is to drain the water and open the foliages at fixed intervals so as to make the sunrays and the outside hot air to enter into the base of the rice plants. This practice chan-

ges the conducive microclimate favorable to the brown plant hopper multiplication and reduce the fulgorid attack.

Biochemicals

In ancient literature many Bio products like "Vidanga", "Asafoedita", Aswagandha tubers, tubers of *Gloriosa superba* etc. are prescribed for treatment of plant pests. But nowadays we could not recognise the nature of the disease described and the medicine except one or two. In olden days, a decoction of equal parts of A safodita, Turmeric and the tubers of "Kanthal Malar" (*Gloriosa superba*) were sprayed by neem leaves for rice disease like leaf spot and pyricularia. The tobacco decoction was also used to control the insects. However some plant products are even now used by village folks. For controlling Rhinoceros beetle, fermented castor oil cake and water is used. This emulsion is poured into small eartern pots and are kept at various places in the affected coconut gardens. The insect is attracted to the smell and killed. Ash is dusted as a desiccant, for controlling the aphids in lab and other leguminous vegetable crops. In rice fields neem cake is applied as basal manure which also helps to protect the rice crop from brown plant hopper at latter stages. While storing gram seeds, the dried leaves of "Nochi" (*Vitex trifolia*) or dried neem leaves are mixed with gram seeds and stored. Sesamum seeds are stored mixed with ash. In villages the gourd seeds like bittergourd, ash gourd etc. are placed inside the cow dung and dried after plastering in the walls. By this way not only the viability of the seeds are maintained but also the seeds are saved from the insect attack. A peculiar practice of storing the seeds of short term rice crop (Kuruvai) is found in Tanjore District. It is called "Kottai" method. First the seeds harvested during September - October will be dried and stored in gunny bags. These stored seeds will absorb the hygroscopic moisture available during the ensuing wet period of North East Monsoon. Therefore these seeds will be dried in the sunshine during January - February called in Tamil as "Thaikaichal". It will reduce the moisture so as to prevent the insect attack. Afterwards the seeds will be stored in a tight container and will be plastered with cowdung paste, dried and stored. This practice is called "Kottai" method. The "Kottai" will be stored till the next sowing season. The cowdung plastering prevents the seeds from insect attack but will not hinder the biological activity of the seeds inside.

Biological methods

In agriculture the whole Agroecosystem itself helps inthe crop protection. Presence of trees and shrubs in the bigger field, bunds and borders supports the nocturnal

birds like Owl and the Reptiles which feed on the rodents and other insects. A folk saying is that if tall trees are found in the border of the farms, it is deleterious to the field rats. Instead even small trees or bushes in the inner bunds will help field rats. Another folk saying also stresses the importance of Avian fauna for plant protection. It is said that "if Indian Pitta (a migratory bird) is found in large number during the month of "Ippasi" there is no need for bon fire during the "Karthigai" month. This means that the Indian pitta will eat the insects and therefore there is no need for light trap (Karthigai bon fire) during next month. Further certain practices and social customs also help in the biological control of insect pests. In parts of Tanjore and Thiruchy districts the ducks are allowed inside the fields after the harvest of the short term rice crops (Kuruvai). These ducks not only eat on snails or small fishes but also feed on the insects found in the stubbles. Further they also feed on the insects found in the bounds. By this way the next crop is saved to some extent from the pests. In some localities swine are allowed in the field to eradicate nut grass. By allowing the swine constantly for two or three years and with other agronomic practices, the nut grass problem is solved considerably. Certain social customs like preventing the killing of snakes in the field bunds helps to control rats. Again in the coastal villages, lot of cranes, terns, and green shanks can be seen feeding on the insects in the transplanted rice crops. In certain villages, the villagers will not allow anybody to either shoot or disturb these birds. Farmers used to say that if large number of cranes are found in the field, there will be a bumper crop. Using of trap crop is another method wherever striga is a menace in sorghum. Trap crops like cowpea, field bean, castor etc. are sown well in advance and the weed seeds are tempted to germinate. Then these weeds are destroyed by ploughing and the main crop is grown. By this way these weeds are controlled.

Yet there are and may be many more practices adopted by the farmers for protecting the crops. These practices have to be identified and documented.

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LESSONS FROM TRADITIONAL SRILANKAN AGRICULTURE

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Sri Lanka with over 2500 years of recorded history had its civilisations flourished within an indigenous farming system with its irrigation systems which still excite admiration. The population and development work gradually shifted towards wet zone and maritime provinces from dry zone with the invasions by European nations, but at present development is focussed back again on dry zone. The people here continued traditional agricultural practices in the eco-system in which they were almost self-sufficient in food and energy. The renovation of major irrigation systems, green revolution, advent of agrochemicals and mechanization forced the farmers to change to more capital-intensive cultural practices.

Agnes Kiss of Environment unit of World Bank in a background paper in November 1987 has cited three important factors for increased pest damage to crops. They are as follows:

"The reduction, or ending, of crop rotation and the practice of letting land lie fallow for a year or more; some pests specialize in one crop and tend to disappear when a new crop is planted or the land is allowed to rest.

The planting of large areas with a single high-yield crop that is often susceptible to pests and may have been developed for other growing conditions.

Increased use of fertilizers and irrigation, and less use of farm labour" (China Daily - Nov. 27th, 1987).

The same paper, enlightening on the discussion of World Bank Meeting states "Diseases and pests, ranging from weeds to worms, are responsible for a loss of 45 per cent in food production, the world bank says. For some countries and crops the loss can be as high as 80 per cent". Over a few decades it was evident that production was uneconomic due to high prices of agrochemicals and due to their indis-

criminate use causing environmental pollution and poisoning. If these dangers are realised agriculturists and technologists have to look for alternatives that not only produce enough for increasing population but also protect the ecosystem and environment. Among the traditional Srilankan agricultural practices there are answers and solutions.

It would be easy to understand indigenous practices and techniques by studying the basic unit of society that is the village. The Dry zone village which is known as tank (reservoir) village consists of a tank, paddy fields below the tank, settlement area adjoining the tank and high land forests used for chena (shifting) cultivation. The people of the wet zone also in the olden days mention a tank which was not on the surface but underground, that is, in the forest. This shows the importance of forests for farming which is neglected now.The forests of wet zone hill country fed the perennial streams and rivers that irrigated the dry zone.

The tank village could have been the ideal structure for the terrain of the dry zone. The land is not uniformly flat. It is undulating, a bund between two humps make a small tank that would store gravitational water during the monsoonal rains for irrigating paddy fields below. Drainage water and spillover water from one tank flow to another below it makes for a cascade of tanks as shown in Fig.1 and 2. Besides this there had been dams, weirs and cannal systems too. Fig.3 illustrates the system.

Due to uncertainty of rains and clayey nature of soil preparatory tillage was begun with few inches of water in the fields only when the tank had sufficiently filled. The work on chena began much earlier than paddy field work normally at the end of Yala (south west monsoon) in July and August. The farmers cut the jungle, heaped, burnt and errected the fences before Maha (north east monsoon) season. Seeds or long-aged varieties of crops as a mixture were sown either at the beginning of the rains or just before inter monsoonal rains. The crops grown in maha were highland paddy, kurakkan (millets) maize, ground nut, chillies, pumpkins and melons. With this practice, soil and moisture conservation is partly possible because of the ground cover established by crops before the torrential rains of maha season. Early planting can help towards a high rate of plant nutrients recovery by crops from soil by not allowing them to leach and to be washed away.

Once the sowing of crops in Chena was over farmers returned to the paddy fields. As a practice, long-aged paddy was sown in maha season unless the rains or

A CASCADE OF MINOR TANKS

(Extracted from Anuradhapura - one inch sheet)

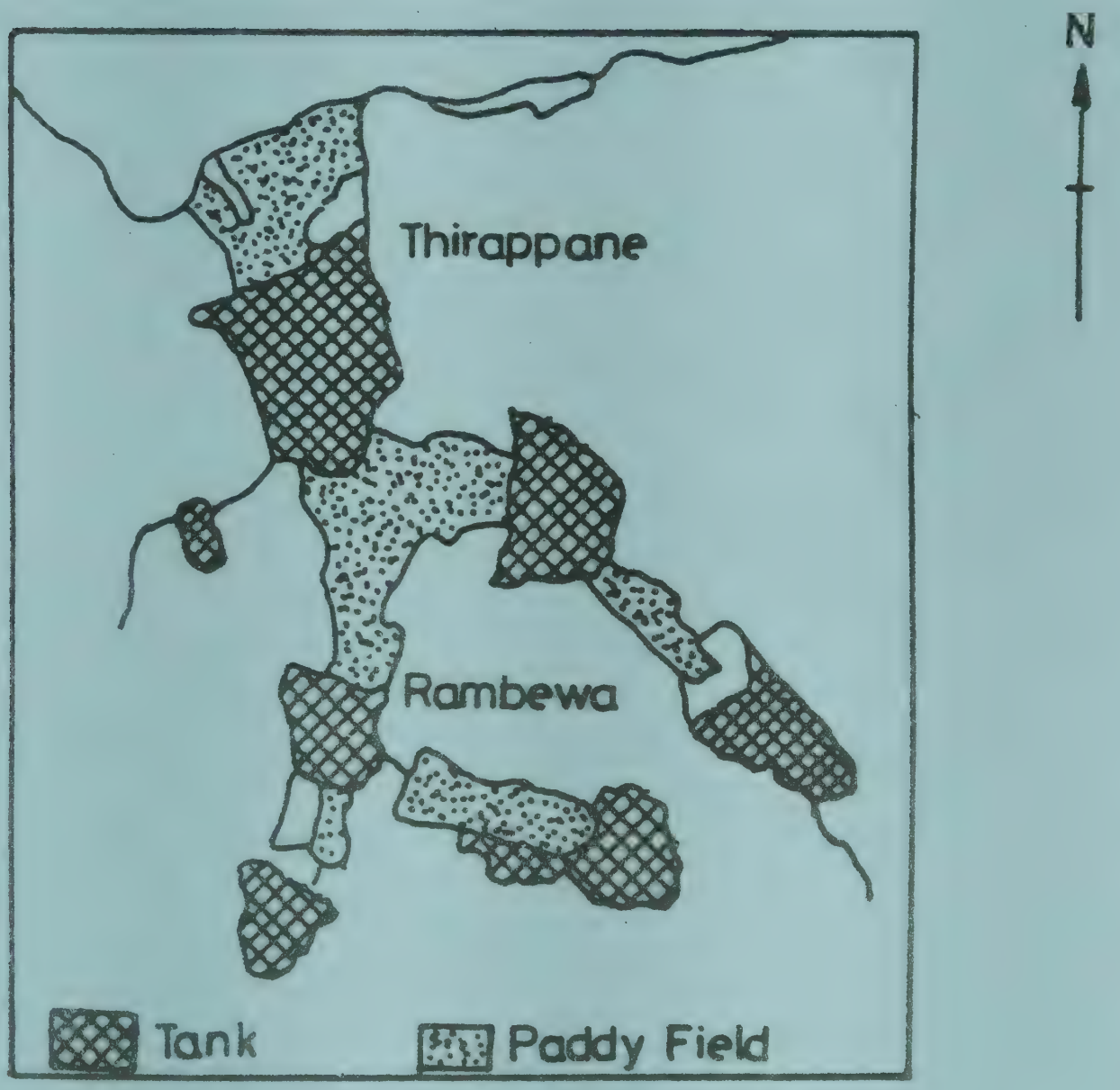

Figure. 1

WALAWI BASIN DEVELOPMENT
ANCIENT DISPERSED SMALL SCALE SYSTEM Vs MODERN CENTRALISED LARGE SCALE SYSTEM

Figure 11

ANCIENT SYSTEM OF IRRIGATION AND DISTRIBUTION OF WATER

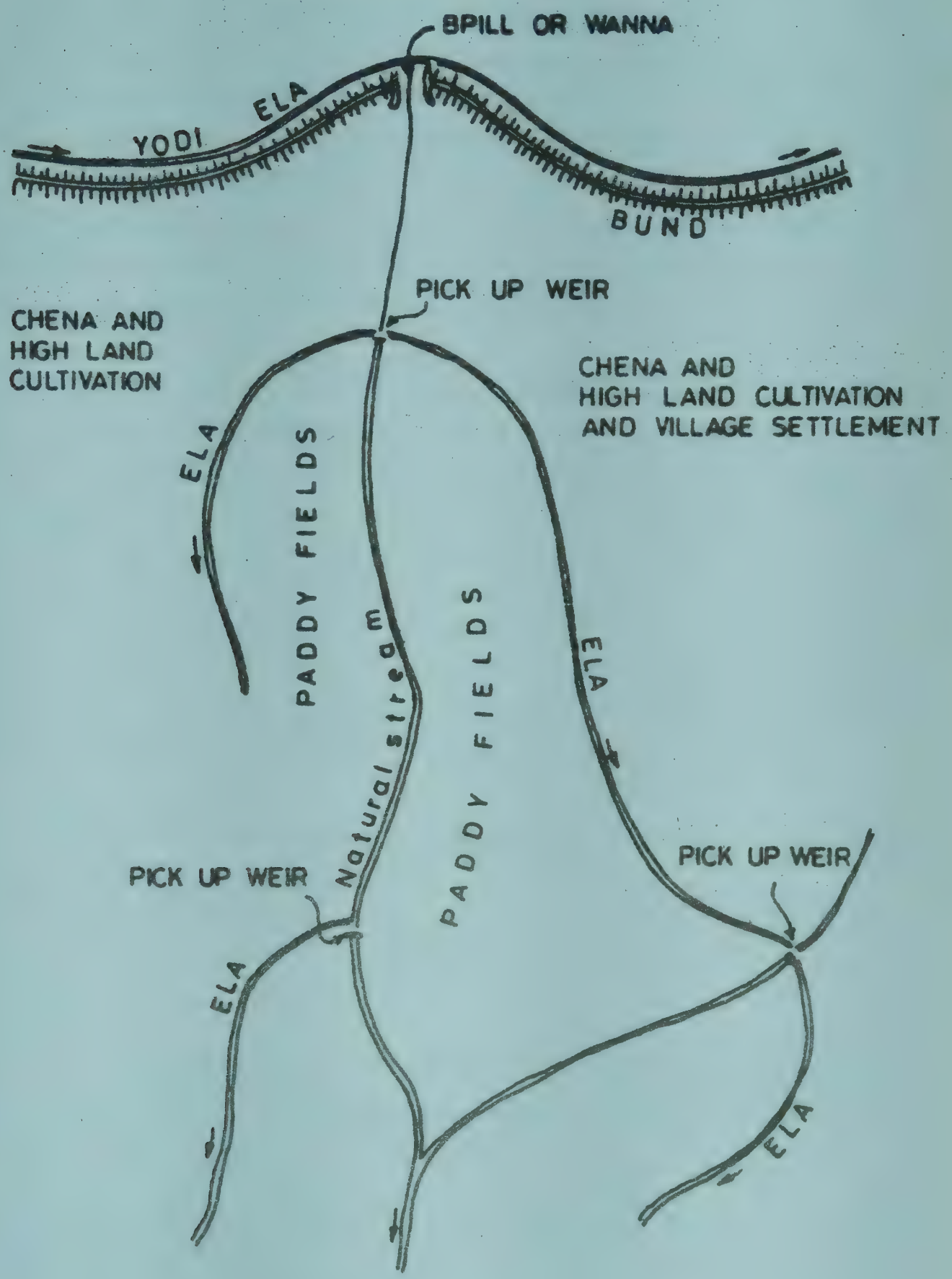

Figure. III

preparatory tillage happened to be delayed. When there was a delay, short-aged paddy was sown for the harvest in the dry months of the season, January and February and never later in order to avoid crop damage by pests and rains. The name given to Thrips attack is *Undu Raththa*. Undu means Unduwap, name given to the lunar month that falls somewhere in December. Rathatha means reddish. Thrips attack paddy at early stages. According to the name given it occurs in December. The best way to avoid it is not to sow paddy later than a specific date. If this is adhered to by farmers even now great damage caused by Brown plant hopper can be evaded. After sowing paddy the farmers go back again to the chena, this time to weed and clean mounds and other vacant places to sow a mixture of short aged crops such as green gram, horse gram, gingelly etc.

Chena harvest was done first. Infact for some families maize cobs at milky stage were the only grain available during this period when all grains stored had been consumed. During yala season, only a small extent of paddy land was cultivated. Depending on the quantity of water available in the tank, the extent of cultivation, section to be cultivated, the date of water issue was decided by the community. The varieties grown in yala were normally short-aged. In chena, mixed cropped with crops lasting for two seasons, gingelly and short aged pulses were grown. The sowing of gingelly is timed so that the crop would flower during the full moon day falling in the month of May. The highlands were never ploughed or any deep tillage was done; after burning the thrash only light weeding was done.

A study of these long tested and practised methods reveal the following principles.

1. Timely cultivation
2. Minimal tillage
3. Mixed cropping
4. Adoption of a cropping pattern that coincides with climatic rhythm
5. Indigenous crop protection measures favouring biological control
6. Use of Botanical pesticides
7. Energy self-sufficiency and labour distribution over time
8. Minimum damage to the eco-system

Timely cultivation

The objective here is to utilize knowledge gained out of a long experience of climatic rhythm in order to obtain the maximum benefits of seasonal rains and minimize crop damage and failures. Recently Sigiriya, situated in dry zone, where cultivation of B'onion is popular had followed the normal western monthly calender for establishing nurseries. However a few farmers who were not satisfied with the weather pattern delayed laying nurseries, till the direction of wind changed. In the end there was a general crop failure except for those who delayed the sowing observing traditional clues.

The factors ancient people took into account were wind movement, cloud patterns, animal behavior (those of birds, like swallows, frogs and appearance of large numbers of mosquitoes) position of sun, moon and planets. The Lunar month begins with new noon. In some years there are 13 months instead of 12. The next important is the position of sun. Some farmers do astrological calculations for sowing on a particular week or a day to avoid specific damages such as rat and wild boar damage etc. Truth of these will have to be tested, but should not be abandoned as myth.

There is a proverb enshrining this wisdom "Kal yal bala govithan karanna", which states quite simply, stick to the time and season for planting. Each agro-climatic region developed its own rule of thumb for time of planting. Dry zone sowing for example, in the North, was timed with reference to the lunar month, beginning with the new moon approximately during October. The timing varies from year to year. The formula used is, "Wapmulata biju isisanna" - sow with the beginning of the new moon. In the Dry zone in the south, seeds were sown towards the latter part of September, the timing again depending on the position of the sun and the moon. Elaborate calculations were made in order to avert pest damage and disease. In the Wet zone sowing was avoided when the sun was in Virgo. Precise calculation was made, calculating the moon's position as well. When this indigenous practice was followed, there was reduced damage from pests and diseases. Even today we can avoid brown plant-hopper damage and grassy stunt virus if we adopt timely sowing of paddy.

Minimal Tillage

The second feature is minimal tillage. Paddy fields in low lying areas were accordingly treated with a gang of buffaloes tied together three times, at intervals of about a fortnight, (there was never any cultivator or plough) then levelled and sown. In fields with hard soil or less water, two buffaloes together drawing a

country plow, infact, a light cultivator, were used to break up the soil. Here too, the main operation was treading. Using this method, the depth of land preparation was limited to about three to about five centimetres. Deep preparatory tillage and using tractor drawn implements affect the chemical nature of rice soil due to turning over the soil. Tillage operations on high land too were confined to shallow scraping. Minimum tillage not only saved energy, crops also grew better.

Mixed cropping

The third principle is mixed cropping. In tropics there is sunshine for approximately twelve hours a day. There is sufficient rain and it is often humid and hot. Theses climatic conditions are conducive for continuous growth and reproduction of fauna and flora unlike in temperate regions where distinct seasons exist. Fauna as well as flora exist in a biological equilibrium. There are pests as well as parasites and predators. Multiplicity of trees, shrubs, bushes and creepers of different species and varieties favour many kinds of insects, harmful to the crops as well as beneficial to the crops,thus keeping the harmful insects at a lower level of population that cannot cause economic damage to the crops. Similarly the spread of disease-causing organisms also was restricted. Unless we realise this phenomenon it will be impossible to develop farming systems and cropping patterns for tropics that protect and enhance nature and produce sufficiently for the increasing population. Mixed cropping farming system would be nearer to nature than monocropping, mostly advised by modern agricultural scientists. Mixed planting of perennial crops, known as multi-tier poly culture is a modification of the type of homesteads in Kandyan region of central hills of Sri Lanka. These homesteads are now called Kandyan forest gardens due to their appearance like forests. Multi-tier poly culture can even be adopted with annual, biannual crops and short-lived fruits like banana, papaya and pineapple etc.

In dry zone several crops - grains like kurakkan, maize, pulses and vegetables - are grown together. Sometimes short-age fruits, like papaya and sweet melon, are interspersed. The mixed crop establishes itself fast with the first rains, and covers the soil, so that soil erosion during the torrential monsoon rains is minimized. Mixed crops promote better photosynthesis and reduce competition for plant nutrients owing to differential preferences. The pulses fix surplus nitrogen which is made available to other crops. Crops are sometimes mixed in such a manner that one crop runs for one full year,through the next season. An example is kurakkan and chillies. Once the kurakkan is harvested the chillies spread and cover the soil. The

kurakkan stubble acts as mulch and conserves soil and moisture, controls weeds and finally adds organic matter to the soil.

The benefits from mixed cropping to the farm family are,

a) a steady food supply, notwithstanding weather changes and damage to some crops,

b) extended use of available family labour throughout the season and year,

c) no pest build up, as with monocropping, and no pest control measures are needed.

Another feature is the adoption of different cropping patterns for irrigated paddy and highland. The cropping pattern can be defined as a sequential planting of different crops during different periods of time in the season, or year, depending upon the climatic rhythms, diurnal variations, and expected weather conditions. The benefits of this practice are similar to those of mixed cropping, the two practices complement each other.

Traditional crop protection measures

Land preparation, broadcast sowing and irrigation water greatly reduced the weeds in paddy fields. Only a random hand picking of weeds was needed. In Chenas too hardly any weeding was required for the first four seasons or so, before abandoning the land. Severe outbreaks of diseases were apparently not known. This is not because there was an absence of diseases but because diseases were not a significant problem. However, pest damage was recognized very early in history and control measures were incorporated in religious festivals and in traditional ceremonies known as 'kems', a kind of magic. To give some idea of pest control measures resting on biological control, certain traditional measures taken are described below:

a) Leaving a portion of paddy field adjoining a thicket for consumption by birds. This portion was identified as "kurulupaluwa" meaning bird damage. Though details are not available, this portion may have been cultivated with a paddy variety preferred by birds, so that bird damage to the main crop was minimised. The underlying purpose was to attract birds so that they would pick off the insects.

b) There were community orchards belonging to all the farmers. The fruits could be enjoyed by any one. Common visitors to these orchards were birds. During off seasons it was a feeding ground for them. With a good bird population pest damage was minimal.

c) Out of the many religious functions and 'kems' one or two are explained to indicate the theory behind these traditional practices. When leaf eating caterpillar damage was observed, the following 'kem' was performed. At sunset, about 4.30 to 5.00 pm a round section of a young plantain stem is fixed to a stick driven into mud, forming a small receptacle or platform about 6 inches in diameter. On this, cool rice, pulses, flowers and a lighted wick dipped in coconut oil were placed. This was done in a few spots distributed over the affected and adjoining area. Pest damage is controlled within two days of 'kem' performance. What actually happens is that birds are attracted from far away places by the light. When they perch on the unstable platform, wholething falls on to the paddy field. When the birds pick the fallen food, they see the leaf-eating caterpillars which are a greater attraction to them. This practice has been devised to bring about biological control. The 'kapuwa' of the village 'devale' (that is the person who maintains and performs the ceremonies of the village temple devoted to a local deity) comes with an assistant to the paddy fields at the panicle emergence. This is the time when the paddy bug which suck paddy at the milky stage, appears. The 'kapuwa' while blowing a conch (shell) which emits a sharp note like that of a trumpet, hangs aricanut flowers in several places of the paddy tract. This goes on the whole morning. Every one in the village hears the note of conch and knows the purpose of 'kapuwa' performance. It could be that aricanut flowers are a paddy bug repellant, if it is not the case, at least a reminder of prospective paddy bug damage, which is more or less a pest forecasting.

Botanical Pesticides

Farmers used certain plants for pest control in grain stores as well as in growing crops. The harvested well dried rice and pulses were protected by a little ash and lime leaves. The thrips attack which appears in paddy during early seedling stage is controlled by placing a few chopped pieces of euphorbia with latex at the point of impounding water. There are many other localised practices. Some other examples are

a) *Grillicedia* leaves crushed and spread over the crop. Possibly it may be acting as an insect repellant. The flowers are used to eradicate rats.

b) A creeper called "kuluwel" crushed at the place of impounding water. It is very effective for hoppers.

c) Aricanut flowers are hung at intervals after a religious function. Probably they act as an insect repellant.

There are other Biocontrol practices such as these:

a) A "Kem", where sand from the sacred Bo tree is applied to paddy crop: What happens is that insects fall into the water and insect parasites and fish living in water prey upon them.

b) Sticky gum from Jak or cashew is applied on the back of "kulla" a fan used to winnow paddy and winnowed over the paddy crop. The insects stuck on to the gum.

c) Similarly a rope soaked in gum is dragged over the field.

d) A rough, large broom made of twigs used to clean the paddy after threshing is dragged over the crop. Then insects were either crushed or fallen on to the water.

It had been also a practice to work a water wheel made of bamboo which produces a continuous beat. Sometimes two wasted momoties are also tied together and hung. Producing sounds, according to some research in Japan causes disturbances to mating. It causes reduction in pest population. (Extracted from a discussion with Mr.H.B.Senerath and Mr.A.B.Abesinghe of plant Protection Division of Government Department of Agriculture.)

Energy

When mixed cropped, an early complete ground cover with crops, instead of weeds is possible. This is a cultural practice that smother weeds which reduces the labour needed for weed control. Minimal tillage requires much less energy than conventional tillage. As mentioned traditionally only animal was power used for land preparation. The animal wastes, dung and urine were the main source of manure for land, either brought and spread or dropped when animals were allowed to graze. Organic manure improved soil properties and did not harm the chemical, biological or physical properties of the soil as with inorganic artificial fertilizer. In the manufacture of artificial fertilizers tremendous quantities of energy have to be supplied. With organic manure not only do we save energy but also

sustain the productivity, even there is no addition of manure, due to residual effects and enhanced biological activities. The measures adopted for crop protection that is for weed, disease and pest control in the traditional system did not require energy as with present agro-chemicals. As we know use of agrochemicals is disastorous, by not using them we can avoid disasters as well as save energy which is expensive and needed for many other purposes of development, and for the use of increasing population. Food, Feed, Fuel, Fertilizers and agroindustrial materials are sources of energy needed and produced in a farm. The traditional, rather indigenous practices of ancient Sri Lanka conserve and reproduce the energy sources. As such, some answers, and solutions for problems created by modern untested technologies are found within these practices. The appropriate traditional practices and modern technologies have to be cautiously and intelligently selected to meet present needs. One obstacle the farming community faces in this attempt is the commercialization of farming for profit making. Human development and nature must be our focus and not commercialization as it is now.

In the search for alternatives to present hazardous techniques one concept offered by international organizations is the Crop Livestock and Fish integrated farming. This is exactly what had been in existence in village tank of Sri Lanka for over 2000 years. Presently it has been modified incorporating modern appropriate technology as the three component Crop-Livestock-Energy Integrated Farming System, which fits into small or large farms. Fig.4 shows diagramatically how it operates. The principles and features of the system can be summarised as below.

1. Recycling of wastes: What is called farm wastes, are nothing but unused input resources. Wastes from one component is utilized in the other two components as inputs. The strength of the system depends on the extent to which the wastes are utilized. Theoretically, the system becomes saturated with complete use of wastes and natural resources such as rain and sunshine. This saturation point can never be reached due to generation of more efficient techniques and concepts. The efficiency of the system is governed by the diversity of each component. More diversed the components are more efficient the system is.
2. Incorporate time tested salient features of traditional agricultural practices such as mixed cropping minimal tillage, biological and botanical pest control measures and many others.
3. The system allows changes and introduction of more efficient production techniques, concepts and varieties at any time and in any part of the

system. For example, the use of a new variety is identified, and also a new breed of animals or a cropping pattern.

4. It uses mainly alternative sources of energy such as sun, wind, biogas, produce gas, organic manure etc.
5. The Crop-Livestock-Energy farming system rehabilitates the damaged eco-system and enriches environment.

Conclusion

A farming system that is appropriate to a climatic region has evolved over a long period of time with its own inherent techniques and practices. While retaining the salient features, the introduction of new innovations must be done very carefully giving priority to nature and people over profits. Adoption of Crop-Livestock-Energy integrated farming system appears to be an important practical alternative to present problems of crop production in the face of increasing population and improving the quality of life of our people generally.

CROPS-LIVESTOCK-ENERGY INTEGRATION

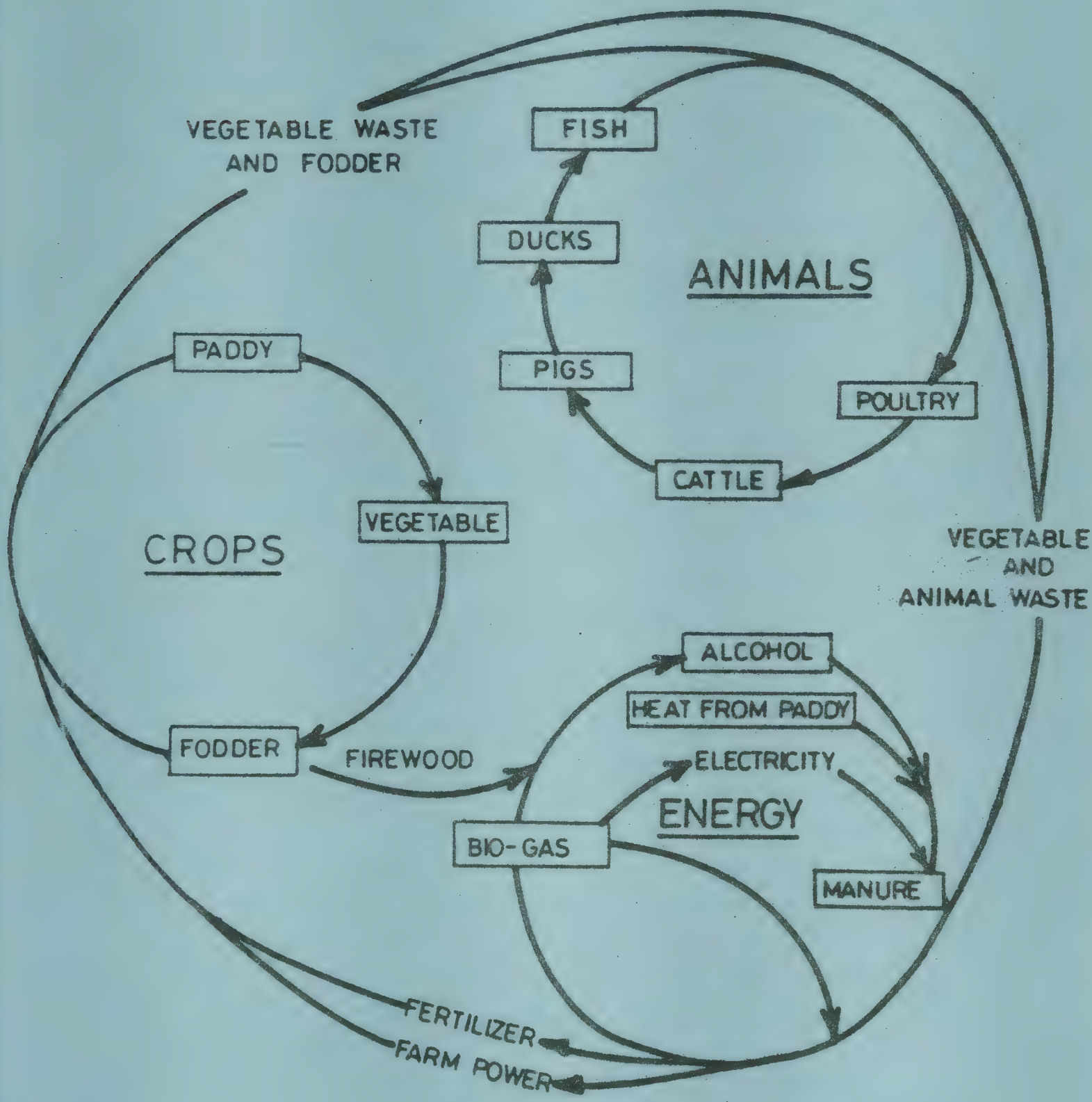

Figure IV

Biocontrol in Practice

EXPERIENCES WITH NATURAL FARMING

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Today's Agricultural Technology, as I have understood, is designed to make the farming community more and more dependent. While the Farm should be a self contained body, nothing should come from outside, not even manure, if at all anything has to come it could be a new seed or Plant vareity. Unfortunately, today farmer is depending on many sources for his implements, manure, seed, fertiliser. weedicides pesticides, and even most of his food. The modern Agriculture is like a cracked earthern pot, which cannot be used but thrown. To come out of this vicious circle, Agricultural technologists should get out of their ivory towers, understand farmers problems and the situation and find out salvation. There is a need for new technologies adopted by successful farmers to be adapted in the package of practices.

Since this seminar is dedicated to Biological pest control, I am happy to share my experiences with the learned participants. We should understand that soil health is the greatest asset of the farmer. Applying chemicals unnecessarily to soil disturbs useful microbes and earthworms. Seed preservation could be done with no pesticides provided they are dried well and stored in natural form. If Banana succurs are immersed for a few minutes in boiling water root nematodes would be completely checked and no chemicals are necessary. If Mary gold flower plants are grown at 15 feet apart both ways the aroma of the plant and also flower would have checked about 40% of insect multiplication in cabbage family crops. Similarly the root excretion of the same Marygold is very much liked by root nematodes which kills them in Solanace family crops. Similarly food grains can be stored safely with dry neem leaves or the leaf paste being coated over the storage basket or bin. Monoculture encourages pest infestation, hence it is better the farmer should go for mixed cropping or strip method of growing crops which discourages pest infestation. Companion planting like Onion and Carrot, Rose and Garlick, Banana and Coconut help each other with pest problems.

Natural enemies like, Birds, Frogs, Snakes should be encouraged to be present around the farm as it helps a lot in pest control. Spraying neem leaf or oil cake decoction, because of its bitter taste and strong repellent odour checks pest infestation. Natural predators like ladybug control aphids, Praying mantis checks most of the insects in Orchards, Spiders could keep control over many paddy pests provided they maintain needed population. Even the hardiest mealy bug has a natural predator. So the farmers should be taught about these great nature"s gifts. Nicely pulverised chilly powder mixed with neem oil is the alternative found by farmers when they found the most dangerous and costliest pyrethorids could not control pest infestation in cabbage and cauliflower. Maida and fine salt power mixed well and dusted over cabbage made the larvae die of thirst. Bright light traps provided in the night at the farms give very good result of controlling insects. Adding 2 to 3 kilos of neem or pungamia oil cake at the basins check root nematodes, white ant infestation and multiplication of mealy bugs. Both the oil cakes are very good sources of nutrients for the plants. The adult root grubs come out of the soil on the first night around 7 pm during the onset of monsoon and feed on the foliage of neem and similar trees. So if every farmer can fix 20 to 25 neem tree branches at his farm on first night of monsoon onset and manually catch up the male ones while feeding and mating on the neem branches, he could stop millions of root grubs being multiplied.

If all the above mothods are adapted one could control almost the whole pest infestation. Even if it is not 100% control it is much more better than 100% control by chemical pesticides at the risk of dependence, economical aspects, apart from the damages to environment, human, animal and soil health. Please believe me it is not important how much more you produce by consuming chemical fertilizers and pesticides but it is how much you are saving from using natural resources without hurting human, animal and soil health, apart from disturbing environment. Thanking you very much for the opportunity given to me to by PPST to share my practices with the learned participassnts.

Jaihind.

PEST CONTROL - LEAVE IT TO NATURE.

Gopalakrishnan and Vijayalakshmi, SARANG, Chittoor P.O. Agali, Palghat District, Kerala - 678 581.

Pest control deserves an important role in the production of food for man - Expert comment. It is the experts who decide what pest control should be. Due to this decision, every man, woman and child consume one Kg. of poison every year. The Green Revolution that began in 1963 declared that not a single child should die of starvation in the world, but still even now there are about a billion (1000x1000x1000) living in acute poverty. The Green Revolution at least proved that poverty cannot be wiped out by marketing hybrid seeds or high production attained by pest control. If you really want to eradicate poverty, poison the pests in the brains of the so-called speakers of the Green Revolution. There are many pests there which consume bright ideas. Many pests have increased which can survive the pesticides used for pest control. But more poisonous pesticides are being experimented with in the name of research. The problem is becoming severe and complicated day by day.

F.A.O. was formed by the U.N.O. to provide expert opinion on the use of pesticides and artificial fertilisers. But who are the members of the working group of the industry co-operative programme of the F.A.O.? VASF, BAYER, BORDEN, BRITISH PETROLEUM, CIBA GEIGY, CYNAMID, FMC, HOECHEST, HOFFMAN-LAW-ROCHE, IMPERIAL CHEMICAL, LIQUE GAS, MERCK, PHILIPS, SANDOZ, SHELL, STAUFFER, WELCOM ! Who does not know that these companies are very big pesticide manufacturing companies?

It is a cottage industry in China which cultures the predators and parasites which kills the pests destroying rice. China is the only country which uses this type of biological pest control on a large scale. They destroy the worms and the like. They release fowls into the fields to get rid of "Munja".

At this time one thing should be remembered. In Kerala, Kuttanad is the store house of rice cultivation. Duck breeding was a cottage industry there. Now, because of poisoning, it is impossible to breed them. So the pests are growing there.

COMMUNITY HEALTH CELL LIBRARY AND DOCUMENTATION

Previously there was no pest problem there. So we know the relationship between the Duck and the pests.

One thing is true. There are arrangements for pest control in nature evolved through tens of lakhs of years. If we are able to study these, if we can create that type of environment, then the nature will do the pest control. This is our strong opinion.

There are some easy methods for pest control which our ancestors used...

1. Find out seeds which have the power to resist the diseases.
2. Grow trees around the fields.
3. Grow plants which are suitable to the region. Avoid other crops even though they may be profitable.
4. Plant seeds according to the season.
5. Avoid plantation crops.
6. Avoid repeated cultivation.
7. Plant some plants, which are detested by the pests, here and there.

It is proved that pests will be destroyed completely by these methods.

Find Out Seeds Which Are Able To Fight Pests

There were good seeds which have immunising power against diseases; seeds which are suitable for a particular place and a particular climate. Even in India, there were 1,20,000 types of rice seeds, which were evolved through thousands of years. This is the case with rice. There were seeds for kinds of plants as well. With the Green Revolution, the world was filled with few types of seeds which we can count on our fingers. And chemicals were produced for them. Thus we have lost seeds which our ancestors used. Let us hope we find these seeds inside the forests.

We at Sarang, are cultivating Tomato, Bitter Gourd, Snake Gourd in the forests. It is not true that we are cultivating, but we look after the plants which grow in the forest. Bitter Gourd was not there in these surroundings. We distributed the seeds in the forest and allowed them to grow.

There are four or five types of Tomato. Very small ones, golden coloured ones, red coloured ones, sour ones and bitter ones. We get tomato for daily use off season also. But last year we used one variety of tomato. One plant gave one kilo of tomato daily for two and a half months. It was spread through one cent of land. This year there was a sudden change in the climate. But little plants are coming up. Tomatoes which we grow are not even 1/5 th of the recent tomato yield. But they taste better. The forest variety of tomatoes has no diseases at all. They have immunisation built in. The same thing can be said about bitter-gourd. It is important to note that nature itself has given the immunisation power to these plants.

Grow Forests Around The Fields Or Trees With Flowers Which Attract Bees And Birds

The land we cultivated is inside the forest. It is full of trees and shrubs which we planted only 5 years before. But it has become the place for the nests of the birds. And there are plenty of flowers and fruits.

There are plenty of doves, which eat all the worms. Another bird called "Drongo" also eats the pests. And there are unknown birds that toil hard for pest control. It is also easy to have a bee-hive inside the forest.

Cultivate Plants Which Suit The Land

The plants which suit the land should be cultivated, otherwise it becomes necessary to use artificial fertilizers.

Cultivate According To The Season

Some plants grow only in some seasons. When we allow them to grow at a time when the pests are plenty, then they will perish. In Kerala, during the South West Monsoon rainy season, a lot of cultivation is done. But when we try to cultivate Peas, there will be at least one dozen bees in a plant. This particular pest is found in plenty during the rainy season. During South West Monsoon, the rain is almost continuous. But, during the North East Monsoon, there will be rain only in the evenings and there will be some gaps as well. Some days there will be sunshine also. This time is ideal for peas. There will be no problem with the pests also.

Avoid Plantation Crops

Some pests are particular to plantation crops. If they are removed from there, they will attack all the other types of crops nearby. One example is the Vettukkili (Grasshopper). This usually attacks coffee plants. When the plants are sprayed with poison these pests move to the nearby fields and eat the other crops as well. These pests are plenty in the forest. They are attracted by the coffee plantations and come to the fields. If we spray pesticides, some will perish, but the remaining will come and feed on other crops, and because of the presence of coffee plants, even other crops are affected.

Avoid Repeated Cultivation

If the same crop is repeated again and again, the pests of that crop will stay there. The soil will lose nutrition and gradually, the plant is unable to grow. The plants become less healthy with each cultivation; and they also lose the ability to repel the pests.

Grow Plants Which The Pests Eat

Neem, Castor, Kammati must be planted near the fields. These plants are like poison to the pests. In olden times these plants used to grow in plenty. And this was another practice as well. A branch of a mango tree and that of Neem was planted in the middle of the field. When there are demonic winds, the rice will grow. May be they are able to prevent some pests. Some research must be done for that. We have decided to experiment with Tulasi and Cotton.

So many pests are there in our fields and forests. But they have not spoiled the crop. We can see spiders, frogs, bees, small birds, and one type of butterfly eating the pests. It is certain that there is a relationship between forest and crops. If we try to spoil that, then we have to use poison.

Natural way of Farming - Some Observations From Mohanpur Experiment

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Introduction

There is a growing concern about the adverse effect of advanced agricultural systems, characterised by the increased dependence on fertilizers and use of pesticides and chemicals. Not only are the long term consequences of the present mode of food production, preservation, and use are in question, but its increasing dependency on a highly unstable marketing system etc., are controversial issues.

It seems that, there are ample proven examples for the modes of doing agriculture, as well as the different ways of living, with totally different perception about life.

Natural way of farming is one such alternative way of farming and living, by continuously but consciously evolving with nature, rather than working against nature. This 'do-nothing' farming gives emphasis on protracted and thoughtful observation rather than on protracted and thoughtless labour.

Masanobu Fukuoka: Man and Life

In a way, the journey towards a natural way of farming is the journey of a man in search of nature. Masanobu Fukuoka, a former plant pathologist by training who was in search of a meaningful way of living evolved into a farmer. For the last "forty years he has wandered about in search of nature". In its philosophical sense, natural farming is this process of re-relating man with self and thus to nature. This process has to convince man that, he is only a part in the complex web of life, and not the designer of it as Chief Seattle described it a century ago.

Principles of Natural Farming

Fukuoka himself observes that his method of natural farming has approached the point of 'do nothing' over forty years, with lots of failures. And now, he spells out

the four major principles viz., no cultivation, no fertilizer, no weeding and no pesticides.

Being critical of the ploughing methods, especially associated with modern machine-based agricultural system, in natural farming the ability of the soil to regenerate and plough itself with the organism within and be sustained by it, has been given importance.

Crop depends on the soil for growth. Soil itself has the ability to enrich itself, provided human activity is within a limit, whether it is agriculture or anything else in that respect. The careless farming practices deplete the fertility and turns it into a desert. "The surest way to solve the problem is to apply a method that adopts to the circumstances and follows". This 'no-fertilizer' principle does not say fertilizers are worthless, but there is no need to apply the same.

Basically because of man's discriminatory understanding of nature, he distinguishes between 'crops' and 'weeds'. In natural farming, the so-called weeds are respected, because they play their part in building soil fertility and balancing biological community.

From the time that weak plants developed as a result of such unnatural practices as ploughing and fertilizing, diseases and insect imbalance became great problems in agriculture. Monoculture and so-called improved seeds contribute a lot to aggravate the situation. This problem, combined with business interest and profit motives of multinational companies is heading towards a crisis in agriculture now.

For Fukoka, farming is not simply an activity that produces food. It is an aspect of the extension of his world-view. "The path I have followed, this natural way of farming, which strikes most people as strange, was first interpreted as a reaction against the advanced reckless development of science. But all I have been doing, farming out here in the country, is trying to show that humanity knows nothing. Because the world is moving with such furious energy in the opposite direction, it may appear that I have fallen behind the times,but I firmly believe that the path I have been following is the most sensible one".

Farming and Natural Farming in India

India has exceptionally rich and highly diversified physical patterns, climatic characters and cultural and agricultural methods, exhibiting complex compositions, and affinities. The ecological prudence of these traditional societies are worth studying. In India, traditional systems of agriculture give more emphasis for production to meet the food needs of the cultivators, than to the surplus for exporting to market. Thus pressure on soil and environment was limited. Crop rotation and crop diversity along with diversity in agricultural practices evolved over centuries, provided a sound scenario, until recently the British rulers and Independent Indian rulers, modernized this sector for producing marketable crops primarily.

Another trend was an experiment of Rishi-Kheti, chosen by Vinoba Bhave, It aims at the purification of human character and sustenance. This sarvodaya method involves organic methods of cultivation with human labour replacing animal labour.

But natural farming was pioneered in India by Sri Pratap C. Agarwal and the workers of Friends Rural Centre, Rasulia. They call it rishi-kheti or regenerative agriculture. That was an attempt, for the first time, along the direction of the principle enunciated by Fukuoka. As a first step, they stopped the use of artificial pesticides and fertilizers. Soon after they stopped using tractors and ploughing. successively steadily increasing the variety of crops grown, undertaking multiple cropping etc., so that weeds and pests are controlled.

Inspired by the experiments in Rasulia, Raju Titus, a neighbour of Rasulia also converted his farm into the rishi-kheti farm.

There are some other places like Sarang(in Kerala) and individuals also trying in this direction. In experimental terms, the interest in natural farming is increasing all over the country. People from different avenues of life are starting to work on these lines. For the last two years, an attempt is going on in Mohanpur village of Bijnor district in U.P., which we will discuss here in detail.

Mohanpur Experiment

Location and Ecological History

Mohanpur is a small village in the district of Bijnor in Uttar Pradesh, where this effort in natural farming is going on. This village is a part of the Indo-Gangetic plain, remarkable for its dead flatness, the gentle slope seaward and the immense thickness of alluvium. The ecology of this region, is determined by the presence of the

Himalayas in the North, by the presence of the increasing human population, recent rapid urbanization, and spread of industries. "The ecology of the region is essentially human ecology, in which plants and animals and abiotic factors play rather an insignificant role".

This area originally had a natural vegetation of monsoon-deciduous forests upto the 16th century. The combined effect of new working forces and administrative reforms resulted in the formation tracts, with only scattered relics of resistant woody plants (thorn srcub vegetation). With the introduction of new marketing system and infrastructural facilities and technological breakthroughs, monoculture of commercial crops dominates almost the entire area.

In Mohanpur region, sugarcane, wheat, rice and fodder are the main crops, irrigated with the help of groundwater tubewells, and sown with the application of fertilizers and pesticides in an extensive manner. Bric kiln is another 'profitable' business with soil in that area, like other parts of the Bijnor district.

The 3 acre experimental plot is circumscribed by fields of sugarcane, rice, wheat and fodder. On one side there is kachha road and on another a brick kiln. The land is irrigated by water from a tubeweli at one corner of the plot.

Way back in October 1983, Shoor Vir Singh, a farmer, set aside about 1.5 bighas (0.3 acres) for farming without chemicals. When he knew about Fukuoka's method, through 'One straw Revolution', and its application at Friends Rural Centre and Raju Titus' farm, he also decided to experiment along the same lines.

The experiment began with the rabi season of 1985-86. Mutter and sarson were sown, and the harvesting was done in April 1986. The output was 140 kilograms of mutter and 25 kilograms of sarson. This mutter output was considerably higher than those of the neighbouring farmers who had used fertilizers. Their's averaged 50 to 60 kilograms per bigha, compared to 90 kilograms on our farm. The sarson output was poor by comparison. Perhaps the unseasonal rains that lashed the area in Feb.-March 1986 was the cause behind this.

After harvesting the mutter and sarson, the rest of the plant and straw were not used as fodder or burnt as is the normal practice, but put back on this 1.1/2 bighas of land to act as mulch.This covered land presented a very different picture from the rest of the neighbourhood, which was naked land exposed to the summer sun.

Slowly, the straw became converted into soil, and various grasses (including those which are regarded very unfavourably by farmers, such as 'dhoobda') made their appearance. So did various insects and other creatures, including snakes.

During the 1986 kharif and 1986-87 rabi seasons, the farmer tried out various small experiments on the 11/2 bighas of land. The rice crop in the kharif season did not give much yield because of the failure of the monsoon, but the sarson and masoor crop in the rabi season fared much better. Of much greater importance than the harvest, however, are some of the other observations that Shoor Vir reports. One is regarding the ability of the roots to keep themselves alive because of the 'no tilling' policy, with the result that in a new season the plants can yield flowers and fruits even without being sown. The other is the ability of the plants to grow and yield healthy grains despite the presence of so-called 'competitive' or 'dangerous' weeds and grasses.

Having watched changes in this small piece of land for a full year, it was decided in April 1987, to work at a more serious level and extend the area under this process to three acres. This area was covered with the cut straw from the rabi crop of 1986-87. Following seeds were broadcasted in the kharif season;

1. Dhan (rice)
2. Uda
3. Bajra
4. Sanai
5. Sann
6. and several other seeds such as arhar, moong, jowar,

so that multi-cropping can be developed. (All these names are local).

The results were encouraging in the case of others, the major crop, the output worked out to be 1.25 quintals per bigha. The urad, bajra, sanai, and sun harvest were also reasonable.

In the rabi crops of 1987, six different combinations of various seeds were sown in the following manner:

The principal objective of this rabi crop pattern was to study the effectiveness and desirability of each combination. We were trying to figure out how well these plants supported and supplemented each other, and also how the land reacted to each of these seed varieties. Unfortunately, despite our best efforts, we were unable to procure indigenous seed varieties for wheat, and so had to be content with the hybird ones. But in the case of all the other seeds what we planted were the indigenous varieties. We left it completely unploughed, and instead covered it with cut straw from the rabi crop of 1986-87.

Weeds and Pests

In this experiment, pests and weeds are *not undesirable.* It is observed that they have their own function in maintaining the dynamism of the system. Insects and plants of different kinds and size are there. All these are part of the emerging community. We know only very little about the numerous ways and forms of inter-relationship between and among these organisms. In a sense, one can say each and every organism has a positive and negative role. So seeing only the negative role and attempting to remove it completely is neither possible nor desirable.

A higher population of insects and plants ensures an equilibrium in which the population of any single organism never increases cancerously. Initially the population of a particular pest may increase alarmingly, but generally the limiting factors also become operative and arrests its growth. For example, in the Mohanpur project, when the white ants were noticed, the farmers were alarmed, but decided not to interfere. And now the farmers do not consider this as a problem. Similar was the case with rats. Also, as white ants preferred mulch rather than the green plant, its role become increasingly helpful. Insects function in the biotic and abiotic community. One has to keep in mind that in this there are pest attacks and heavy doses of pesticides are regularly used by neighbouring farmers surrounding this farm.

Again, as in this farm, always mixed crops are grown, and in the absence of monoculture, there are so many limiting factors which makes uncontrolled increase in insect population an impossibility. The crops growing among other plants are more healthy and resistant to pests and also well protected.

As there are different kinds of grains and insects, birds of different kinds come. Of course they eat up insects and grains, especially meant for seeds, soon after sowing. The number of snakes that come to the field has also increased. Another

reason for the increasing number of birds coming to this field is that there is hardly any other farmer in that area is growing the same grains, because of increased pressure on them to produce commercial crops.

A 'pest' locally known as Kamala was there in this region in the last season. It eats urad. Normally when there is an attack from Kamala, farmers give up on the grain part of the plant, and expect the plant to serve as fodder. But in this plot, even though this supposingly 'disastrous pest' was there, the output was better compared to other farmers. The neighbouring farmers also enquired and took note of this incident.

There are of course many factors which contribute to the functional complexity and efficiency of a natural system. The numerous ways of inter-relations between these factors, especially when they are organic and alive in nature is beyond any amount of structuring and making equations. This is the point which Fukuoka emphasises when he continuously warns against 'scientific method' coupled with human arrogance, that simplify the complex systems.

Conclusions

No organism detached from its natural setting works in a simple linear way. The inter-relations are complex and inter-connected in many ways. Any approach to wash off any organism from an ecosystem has its own consequences. Nature does not allow an ecological vacuum, and when there is less diversity, more 'weeds' will grow, when there are enough, diverse, native plants in that region, the so-called weeds will vanish.

Most important thing, with respect to the pest control in Mohanpur is that pest was never a problem, and there has been no observation, till now, of a severe pest attack. This absence of observation is a clear indication of the absence of pestt problem, even though there were alarms twice or thrice over last two years. Nature controls insects in its own way, in the natural way.

Our observations are not that systematic due to many reasons, and our conclusions are tentative, and open. After all two or three years are nothing on an evolutionary time scale, in which nature works, The difficulty in getting indigenous seeds and the smallness of the plots etc., also become constraints. This period has been large-

ly a period of drought, and the tubewell also broke down two or three times. Farming in general has been bad.

We are not suggesting here any method of controlling the pests. All what we are saying is that in the natural way of farming this problem of pest does not seem to be there. However, much more efforts are required

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Mass Culture of Biocontrol Agents

NOTES ON CERTAIN COMMERCIALLY AVAILABLE BIOLOGICAL CONTROL AGENTS

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Biological control is the method of controlling pests by making use of their natural enemies (i.e., parasitoids, predators and pathogens) which are purely beneficial.

Ready availability of the required quantities of healthy natural enemies for timely releases is an essential pre-requisite for undertaking practical biological control. This calls for establishment of insectaries. Countries like the U.S.A., the U.S.S.R. and China have taken the lead in establishing such insectaries where mass-production of parasitoids and predators are undertaken. It is reported that there are some 40 commercial insectaries in the U.S.A., about 7 regional laboratories in the U.S.S.R and a number of production units in China which annually produce millions of parasitoids and predators for control of a variety of pests. In India, a beginning has been made by Pest Control (India) Ltd. by establishing "Biocontrol Research Laboratories" (BCRL) at Bangalore in June 1981 (Ridgway and Vinson, 1977;Dietrick, 1981; Manjunath, 1984).

Biocontrol Research Laboratories (BCRL) is the first and only commerciai insectary in India. The activities of BCRL include identifying promising natural enemies of key pests; developing economic mass-production, packing and release techniques; supplying required natural expertise; and to popularise biological control as a practical method of pest control. Unless the farmers are assured of a dependable source of natural enemies, they cannot be expected to practice biological control. BCRL is trying to fulfill this need as far as possible. Now, a number of farmers from different parts of the country have been relying on parasitoids and predators that are being produced in our insectary for control of sugarcane bores, cotton bollworms, coconut black-headed caterpillar, mealybugs, scale insects, etc. For the

benefit of farmers and other readers, brief notes are given on some of these natural enemies.

Notes on biological control agents

Trichogramma Parasitoids to Control Sugarcane Borers, Cotton Bollworms, Apple Codling Moth, etc.

Trichogramma species are amongst the most important and widely used parasitoids for control of variety of lepidopterous pests throughout the world. In India, different species of *Trichogramma* are available for control of sugarcane borers (i.e., early shoot-borer, internode-borer, stalk-borer, top-borer, etc.); cotton bollworms (i.e., spotted bollworms, pink bollworm, *Heliothis armigera*); apple codling moth, etc.

Trichogramma is an egg-parasitoid. The tiny adult parasitoids which remain active in fields, locate the host eggs and parasitise them, i.e., the parasitoid lays its own eggs within the eggs of the pest. On hatching, the parasitoid larva feeds on the host egg and completes its development within. The parasitised eggs turn black, an invaluable diagnostic character, in 3 to 4 days and adult parasitoids emerge in 7 to 9 days. Thus, instead of the pest larvae hatching from the eggs, the parasitoids come out. A single parasitoid can thus destroy over 100 eggs of the pest.

Trichogramma kills the pest in the egg stage itself before the pest could cause any damage to the crop. It is a purely beneficial insect.

Releases of 40,000 to 1,00,000 parasitoids/acre are recommended. The parasitoids are supplied by BCRL in the form of "Tricho Card". Each "Tricho Card" carries 20,000 *Trichogramma* parasitoids.

Parasitoids To Combat Coconut Black-headed Caterpillar

The coconut black-headed caterpillar is a serious pest of coconut palms. The caterpillars feed on green portions on the underside of leaves, mostly on lower fronds. They remain concealed in galleries formed of silken webs and excreta. Severely affected fronds dry up, weakening the palm and reducing the yield.

Two larval parasitoids, namely *Goniozus (=Parasierola) nephantidis* and *Bracon brevicornis*, have been found to be promising for controlling coconut black-headed caterpillar.

When the parasitoids are released in the field, they go in search of the caterpillars feeding on coconut leaves. On locating a caterpillar, the parasitoid paralyses it by stinging and lays up to 12 eggs on it. The eggs hatch in 1 or 2 days. The parasitoid larvae feed on the paralysed host and complete their development in 3-4 days. They form cocoons on or near the remains of the host. After 7 to 10 days, adult parasitoids emerge and go in search of fresh caterpillars. A female can lay up to 120 eggs and these are distributed on several caterpillars. Thus, the caterpillars are killed while the parasitoids multiply themselves. Releases of 1,200 to 1,800 parsasitoids / acre / season are recommended.

Ladybird Beetles to Devour Mealybugs and Scale Insects

Mealybugs and scale insects are serious pests of a number of agricultural and horticultural crops. These insects which hardly move, build up thick colonies on leaves, stem, fruits. etc. and suck the sap from the plants. Besides such direct damage, these pests secrete a sticky substance known as "honey dew"on which "sooty mould" fungus develops; consequently, the infested surface becomes black. Heavily infested parts shrivel and drop or become so sticky and unsightly as to render them unfit for marketing or consumption.

Three species of ladybird beetles, namely *Cryptolaemus montrouzieri, Symnus coccivora* and *Nephus* sp., can give effective control of mealybugs infesting coffee, citrus, grapevine, mango, etc.

Similarly two other species of ladybird beetles, *Chilocorus nigritus* and *Pharoscymnus horni*, destroy scale insects damaging sugarcane, coffee, sapota and several other crops.

The adult ladybird beetles, being winged, search for mealybugs or scale insects and feed on them throughout their life. They live for about 45 days. They lay their tiny eggs in the colony of the pest. Each female can lay 100 to 250 eggs or more depending upon the species. Eggs hatch in 5 to 6 days and the grubs voraciously feed on all stages of the mealybugs or scale insects. They are particularly fond of egg sacs and gravid females, and often completely wipe out the pest colonies. They then enter into the pupal stage, usually in groups, in the crevices of the bark,

fallen dried leaves, in leaf folds, infested plant surface, etc. The pupae do not move. Adult beetles emerge from the pupae in 8 to 10 days. They mate and again start feeding and breeding. Thus, the ladybird beetles destroy the pest while building up their own populations.

A minimum release of 600 ladybird beetles/acre is recommended. The releases are to be made at the first sign of the infestation.

Parasitoid To Control Citrus / Coffee Mealybug:

An exotic parasitoid, namely *Leptomastix dactylopii*, has given good results in controlling the citrus mealybug, *Planococcus citri*. It is a specific parasitoid of this species.

This Encyrtid parasitoid actively searches for mealybugs in fields and lays its egg in the mealybug. On hatching, the parasitoid larva feeds and develops on the mealybug. It completes its development in 16 to 18 days and emerges as adult. The adult parasitoid can live for 30 to 40 days, and each female can lay up to 200 eggs. A minimum release of 2,000 parasitoids/acre/season is recommended.

Parasitoids to Control Housefly and Other Filth Flies

The pupal parasitoids, namely *Spalangia* spp., *Dirhinus* spp. and *Pachycrepoideus vindemmiae*, have been found to be promising and are being mass-multiplied. These parasitoids, if released in sufficient numbers, can play an important role in suppressing fly populations in poultries, dairies, piggeries, dumping yards, etc. where the housefly and other filth flies breed profusely.

The parasitoids of filth flies live within the manure, never becoming pests themselves. The female parasitoids are ready to mate and oviposit immediately after emergence from their hosts. The parasitoid lays its eggs within the fly puparia. The eggs hatch and the parasitoid larvae develop by consuming the fly puparia. Finally, the fly puparia are destroyed as the parasitoids complete their development. It completes its development from egg to adult emergence in 15-18 days. A single female parasitoid lays its eggs in about 100 puparia in about 15 days, thus causing their death as they multiply themselves.

Methods of Supply and Releases

Suitable methods have been developed to pack different stages (i.e.,eggs, larvae, pupae and adults) of the parasitoids and predators and send them to distant places by airfreight/Speed Post/Courier Service/Parcel/Post etc. depending upon the convenience.

The methods of releasing biological control agents are generally simple. The adult parasitoids or predators can be distributed in the field by holding the containers open and walking all over the field. Being winged, they escape and start searching for their respective hosts in the field. The immature stages like eggs, larvae or pupae of the natural enemies are to be distributed in the field by placing them on or in the vicinity of their hosts. Detailed guidance for releasing and handling the natural enemies are available.

Advantages of biological control

1. The parasitoids and predators have the natural ability to search for their hosts and attack them.
2. The natural enemies are capable of self-dispersing and self-propagating so that control is obtained over an entire area and it continues indefinitely. Thus, it will have far-reaching cumulative benefits.
3. No upsets in the balance of nature or resurgence of pests are caused since the biological control agents fit into the ecosystem without disrupting any other components.
4. Parasitoids and predators employed in biological control are purely beneficial. There is no danger whatsoever of the parasitoid or predator itself becoming a pest.
5. Biological control is manipulatable, augmentable and compatible with enlightened integrated control programmes wherein restricted use of chemicals combined with cultural and other ecological methods are employed.
6. Problems such as toxic hazards, residues, environmental pollution, destruction of non-target beneficial organisms, etc. that are commonly associated with chemical control measures, are not encountered in biological control. Hence, it is safe.

Although the concept of biological control is not new, it needs to be popularised amongst the farmers. They must be made to understand that biological control is economical, effective and ecologically sound.

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MEDIA AND METHODS OF REARING *CORCYRA* MOTHS FOR LARGE SCALE MULTIPLICATION OF *TRICHOGRAMMA* PARASITOIDS

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Introduction

With increasing concern over pollution and attendant problems resulting from excessive use of pesticides, a certain amount of interest has been shown by persons connected with the Sugarcane Research and sugar industry in India in the use of natural enemies to control major insects of Sugarcane such as borers.

In early 1930's, bio-control of sugarcane borers *Chilo* species was first attempted with the use of egg parsasitoids, *Trichogramma* spp. In about twenty years, there were reports both of success and failure of these bio-agents. However subsequent trials in Tamilnadu in the 1960's and early 1970's have led to clear evidence of the utility of inundative release of *Trichogramma chilonis* to control the borer - *Chilo saccarophagus indicus*

Ever since inundative release of *Trichogramma* chilonis was proved to be clearly effective in Tamil Nadu in early1970's, to mass produce these parasitoids have been taken up by Tamilanadu Co-operative Sugar Federation, through its Main Bio-Control Research Laboratory at Chengalapattu.

Usually *Trichogramma chilonis* (egg parasitoids) is mass bred on the eggs of *Corcyra cephalonica* strain because it is not possible to collect more number of egg masses of Sugarcane internode borers from the field for this purpose. *Corcyra* cephalonica is an alternate host mass reared on broken grain of sorghum or full grains of bajra or mixed medium of sorghum and rice bran or bajra and rice bran. For the mass rearing of *Corcyra cephalonica*, we need culture boxes of 31cm x 25cm x10cm size.

Large scale Corcyra production procedure

1 Procure jowar or bajra with bold white grains meant for human consumption. The jowar/bajra should not be treated with insecticides (To test this a sample containing 100 gm from each bag is crushed and 20-1st/2nd instar *Corcyra* larvae are allowed to feed for 2-3 days to find out whether the jowar/bajra has previously been treated with any of the insecticide - the conclusion could be drawn based on the basis of mortality of the larvae.

2. The required quantity of the jowar/bajra is milled to make 3-4 pieces of each grain.

3. The jowar/bajra is heat sterilized in an oven at 100°C for 30 minutes.

4. The jowar/bajra is sprayed with 0.1% formalin, this treatment helps to prevent the growth of moulds as well as increase the grain humidity to the optimum (15-16%) which was lost due to heat sterilization.

5. Air drying the jowar/Bajra.

6. Pour 3 kg jowar or Bajra/box.

7. To start with, infest boxes (containing 3 kg of jowar or bajra/box) with 1 ml of *Corcyra* eggs/Box and secure the lid for about 30 days, later on infest at the same ratio three times on 40th, 80th and 120th day.

8. Keep the first lot of boxes in racks and close the lid. (follow the same procedure for subsequent lots).

9. On the 30th day the moths start emerging and the emergence continues for over two months, 10 to 75 moths emerge daily, peak of moth emergence is between 65th and 75th day.

10. Collect the moths daily and transfer to the specially designed oviposition cages. Moths emerging after 90 days of initial infestation are discarded.

11. The eggs are collected which pass through 15, 30 and 40 mesh seives, and run over a slope of paper to eliminate dust particles.

12. The eggs are treated with UV lamp (15wt.) rays for half an hour to prevent hatching.

13. The eggs are glued 10000 eggs per card (12 cm x 2 cm) leaving 1 cm uncovered space at both ends for facilitating stapling. The eggs are exposed to adult *Trichogramma* for 24 hours. After parasitisation 2, 4 and 6 day old parasitised egg cards are prepared for shipment/field

release. A pair of cards are stapled in such a way that the eggs do not touch each other. Ten pairs are packed in each plastic box. For 6 day old parasitised egg cards a strip of wood wool coated with concentrated and dried honey is placed inside the box before closing, so that if an adult parasitoid emerges in transit its saliva will come into contact with strip and this will facilitate feeding. 2, 4 and 6 day old parasitised *Trichogramma* eggs at 10000 each could also be packed in perforated capsules, the perforations will permit predator attack.

Modification in the diet ingredients

A mixure of rice bran:bajra in 1:1 ratio seems to be satisfactory and can also bring down the production cost of the host by more than half.

Table - 1

Effect of rice bran inclusion in the medium for mass culture of the host, *Corcyra cephalonica*.

Details	Host media compared		
	Bajra alone	Bajra+ Ricebran (1:1)	Ricebran+ Sorghum (1:1)
No. of trays observed	150	479	149
No. of moths obtained	72,415	705,852	162,763
Yield of moths per tray	616	1,453	1.092
No. of days required for 50% emergence	107	71	80
No. of days required for 75% emergence	154	108	111
No. of days required for 90% emergence	224	145	165
No. of days required for 100% emergence	257	221	246
Yield of moths/tray/day for 50%	2.9	10.2	6.8
Yield of moths/tray/day for 75%	3.0	10.0	7.4
Yield of moths/tray/day for 90%	2.5	9.0	5.9
Yield of moths/tray/day for 100%	2.4	6.5	4.4

Source: Solayappan(1977)

TABLE - 2

Emergence pattern of *Corcyra cephalonica* adult moths from different food materials.

Particulars	Food Material used		
	Cumbu	Cumbu+ Ricebran	Cholum + Ricebran
No.of trays observed	150	479	149
No.of moths emerged	72,415	7,05,852	1,62,763
Yield of moths/tray	616	143	1,092
No.of days required for the emergence	257	221	246
" " " 90%	224	145	165
" " " 75%	154	108	111
" " " 50%	107	71	80
Yield / tray / day for the emergence	2.4	6.5	4.4
" " 90%	2.5	9.0	5.9
" " 75%	3.0	10.0	7.4
" " 50%	2.9	10.2	6.8
Cost of food material per tray	Rs. 3.00	Rs. 2.00	Rs. 2.40

It was also found that about 75 per cent of the moths emerge in less than 4 months with this cheaper medium as against over 5 months on bajra alone. Hence, the cheaper diet would enable the waiting period for productive trays to be reduced to below 4 months which enables efficiency and quicker turnover. A method of maintaining the host culture with the least manual labour has been suggested by Parshad (1975), which might also be of use in minimising the production cost of the host.

The yield of *C.cephalonica* moths were superior in rice bran mixed food materials than in *Bajra* alone. It was also observed that addition of rice bran to the food materials resulted in reduction in the duration required for the development of adult moths. The number of days required for full emergence was 221 in bajra, rice bran mixture while it was 257 days for bajra alone and 246 days for jowar-rice bran mixture. Bajra-rice bran mixture feed gave the highest moth yield per tray for a day for the full emergence of moths. When the production efficiency of adult moth was compared the yield was 10.0, 7.4 and 3.0 for bajra rice-bran mixture, jowar-rice bran mixture and bajra alone respectively. The cost of food material is 30 percent

less than that of the normal one per tray with a simultaneous enhancement in the yield per day. Metcalf and Brewiare (1969) have indicated that the cheap sources of mass production of *Trichogramma australicum* continue to be on the eggs of grain moth although phytophagous hosts such as moth borers and Saturnids can also be used as host. The possible reason for increased moth yield when rice-bran was mixed with either bajra or jowar grains might be due to the increased availability of nutrients. Gopalan et al (1971) have reported that rice bran contained 13.5 per-cent. fat and carbohydrate content was also higher than the other two grains (Table 3). Among the two grains viz.bajra and jowar, bajra is more nutritious than jowar grain.

TABLE - 3

Nutritive Values Of Ricebran, Cumbu And Cholam

Nutrient	Ricebran	Cumbu	Cholam
Protein	13.5	11.6	10.4
Fat	16.2	5.0	1.9
Carbohydrates	48.4	67.5	72.6

Another possible improvement appears to be in standardising appropriate ratios of parasite : host eggs, for efficient parasitisation in the laboratory. While the present ratios are 1:3 or 1:4 in most centres, there is scope to widen this to 1:10, which has been found to be optimum for parasitisation by females of *T.perkinsi* (Tuhan and Bindra, 1975). Such breeding work can bring about savings in the overall cost of production. Further, they might also offer an indirect benefit by reducing the changes of superparasitism.

Care and maintenance of host culture

A common problem in successful maintenance of the host culture is the incidence of parasites and diseases. The parasite, *Bracon hebetor*, causes considerable mor-tality of the host larvae. Removal of fresh cultures to a separate room, trapping the emerging parasites with sticky surfaces around lights and spreading a thin layer of ash on the media in the trays would offer some relief. A double-layered mesh or cloth fixed to the lid of the trays will provide considerable protection from fresh

parasitism. The other mortality factors include a bacterial disease and a nuclear polyhedrosis virus as well. The former is characterised by blackening of the body surface and exudation of dirty brown fluid from the ruptured body wall and could be checked by treating the culture trays with 0.001 percent aqueous sprays of streptomycin Sulphate (10 mg/litre of water). Virus infected larvae turn chalky white and become flaccid. Rejection of the infected trays would be helpful in checking further spread of the disease.

To maintain the vigour of the host culture, considerable or complete replacement with insects collected from warehouses or other infested sources once in 3-5 generations should be effected. This will obviate physiological and genetic decline of productivity of the host culture.

Conclusion

Ample scope exists for enhancing the benefit of parasitoids through the rearing of alternate host (*Corcyra cephalonica*) on cheaper feed materials, simplified handling method and optimum host parasitiods ratio for laboratory multiplication. The future appears to be bright for extensive adoption of these practices.

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NOTE ON THE ACTIVITIES OF MAIN BIO-CONTROL RESEARCH LABORATORY OF TAMILNADU CO-OPERATIVE SUGAR FEDERATION LIMITED.

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Tamil Nadu Co-operative Sugar Federation has successfully implemented a pioneering scheme on recent Agricultural Technology, such as biological control of sugarcane pests and use of bio-fertilizers. These programmes emphasise the scope for non-chemical technology and benefit the agricultural environment on a long term basis. In advanced countries, the hazards of complete dependance on chemicals are becoming increasingly realised and their agriculture now emphasises biotic agents as an integral part of crop management technology. At present, the Federation caters to the needs of the 15 sugar factories in Public Sector and Co-operative Sector in Tamilnadu, to some extent, in implementing biologically based technology.

Presently, there are 3 major inputs which will fit in with this technology. The first is the use of an insect parasite that effectively control the major part of sugarcane in Tamil Nadu. This parasite (*Trichogramma*) is now mass produced in millions of our Main Bio-control Research Laboratory at Chengalpattu. *Trichogramma* is being released at the rate of 1,20,000 adult parasites per acre for controlling the major pest-internode borer (*Chilo sachariphagus indicus):* No other method of control, such as insecticides or resistant varieties or cultural practices, are found effective or economical against this pest. Further, improved rearing methods followed in the laboratory not only enable an annual production of about 150 million insect parasites to cover 12,500 acres; but also keeps the cost of production at a very acceptable level of Rs.24/- per 1,20,000 adult parasites needed for an acre of sugarcane crop.

A significant and recent finding of the Sugarcane Breeding Institute, Coimbatore is the use of an insect killing virus for controlling another important pest of Sugarcane -the Early Shoot Borer *(Chilo infuscatellus)*. This finding has been recognised by the Indian Council of Agriculture Research as outstanding and the coveted Jawaharlal Nehru award has been conferred upon Dr. S. Easwaramurthy, the scientist who was responsible for this discovery. The Federation has promptly followed up on this finding and taken up mass production of this virus for large scale adoption. The virus, as any other insect killing virus, does not cause any harm to other animals including human beings, so, the use of this virus does not pose any hazard either to the people employed for spraying on the crop or for any other organism in the sugarcane crop environment. At present, 5000 liters of the Virus suspension are annually produced at the Main Bio-Control Laboratory, Chengalpattu to cover 10,000 acres.

Yet another technology that is finding more and more importance in several crops, is the use of Bio-fertilizers. Field trials on sugarcane in our state have clearly shown that this input is able to bring down the fertilizers bill by supplementing the nitrogen requirement of the crop. Two types of bacteria *Azospirillum* and *Azotabacter* - which commonly abound our soils but are not present in sufficient numbers- can be cheaply mass produced and supplied in an easy to handle form as packets. These, when applied to the soil, augments the nitrogen captured and made available to the crop. But this will not affect the atmosphere which is in dynamic equilibrium. Such bio fertilizers not only help reducing the cost invested but also reduce the demand for the chemical fertilizers. To cover an acre, we only need 2 Kgs. of bio-fertilizers (8 packets of 250 gms. each) and present cost is Rs. 48/- per acre. The benefit to the farmer by way of reduced fertilizer cost will be about Rs.110/- per acre, apart from other environmental benefits. At present, the Main Bio-Control Research Laboratory at Chengalpattu caters to about 20,000 acres by producing and supplying the needed quantity of bio-fertilizers. Supply of these three biological inputs for sugarcane in Tamilnadu are very impressive, compared to other states in India as well as most other developing countries, but we cannot remain complacent, since only a limited area is now being covered in relation to the total area under Sugarcane in our Sugar mills.

The two important pests - Early Shoot Borer and Internode Borer are common in all the factory areas in Tamilnadu and both the pests are known to cause significant loss to the farmer (field loss) as well as to the industry (factory loss). At least in 30-40% of the total sugarcane area in the state these pests are more severe and this

should receive complete coverage with the parasite, *Trichogramma* and *Granulosis* virus. Further coverage of the sugarcane area with bio fertilizers should be augmented so that the entire area is treated once in 3 to 4 years. This is important especially for maintenance of soil health. Accordingly the mass production and supply of bio-fertilizers should be augmented to cater to at least 25% of the area under the mills in each year, so that at least once in 4 years the entire area will be covered.

Increased efforts are required to sustain the pioneering technological progress made by the Tamilnadu Co-operative Sugar Federation i.e., use of Bio-agents in sugarcane agriculture. Earlier attempts to expand such activity by crssseating more centres in different parts of the state do not seem to be successful. The likely reason is the lack of qualified and day-to-day supervision, which is very essential in mass production of biological agents. Therefore, future efforts should be directed towards strengthning the present Main Bio-Control Research Laboratory at Chengalpattu which has already proved capable of producing and distributing of these agents very effectively. Strengthening of this centre by increasing the man power, basic equipments and transport facilities so as to enable adequate and timely production and distribution of these bio-agents would be a valuable step in this practical and large scale use of bio-agents in sugarcane agriculture in our state. The support for such efforts is both essential and urgent, considering the benefits to the sugarcane agro-eco-system and in turn to the farmers as well as the industry.

Biocontrol with specific agents

BIRDS AS BIOCONTROL AGENTS: A PERSPECTIVE ON AVIAN USE OF THE AGRICULTURAL ECO-SYSTEM IN INDIA

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Birds have in this country traditionally been recognised as important components of the agricultural landscape. It is however unfortunate that a common tendency has been to emphasise the more apparent degradations of large flocks of granivorous and other birds like ducks, geese and cranes. This attitude has often masked the considerable toll that birds take of harmful pests like locusts and aphids.

If one were to consider the influence of birds on agricultural eco-systems on a scale which had an optimum equilibrium (where benefit would approximately be equal to harm) as its origin, then on one end of the scale where pesticide use was heavy, we would have significant decreases in ground bird numbers (via a reduction in insect abundance) with a consequent drop in crop yield; at the other end of the scale where a monoculture-type crop regime was prevalent, there would be an overabundance of a few 'destructive' species like parakeets and sparrows, once again resulting in a drop in crop yield.

In the United Kingdom, the Game Conservancy has for over 35 years carefully monitored both gamebird (particularly Grey Partridge and Pheasant) numbers and the multiple factors within the agricultural eco-system, both natural and man-influenced on which these bird numbers depend. An extensive analyses of this data has now enabled the Game Conservancy to make several valuable practical suggestions to gamekeepers and farmers on how best to maximise the productivity of their respective 'crops', and yet have a sustainable yield over several years. What has usually not been recognised by agricultural scientists in this country is the central importance of species-specific life history studies which evaluate every phase of a bird's life in the context of food habits and social behaviour (flocking, local movements etc.) from hatching to death. As far back as 1935, Dr. Salim Ali

had submitted a proposal on 'Economic Ornithology' to the then Royal Council for Agricultural Research (now ICAR), stressing the importance of life history studies and an assessment of the balance between harmful and beneficial insects in bird diets.

The project was shelved at the time, and still awaits a revival; the time for taking up such a project would be most appropriate at the present time, given the rapid change in agricultural land use. A primary focus of this approach would be to quantify and compare the numbers of harmful (to crops) insects vs cultivated grain eaten by different species in different seasons.

It would be important in these studies to determine the phase of the crop cycle when birds of a particular species spend the maximum time in crop fields. There are two important reasons for this: Harmful insects often invade fields (or in sedentary species, cause maximum damage to them) at a particular phase of the crops' growth. It has been demonstrated for some bird species like the Starling (*Sturnus vulgaris*) in Europe - a species that occurs in large flocks over northern India in winter - that there is a close synchronisation between the period of maximum locust infestation and the presence of large flocks of Starlings. This suggests that the primary reason for the Starling invasions is the abundance of insect food, and the damage to standing crops by them is secondary and often mechanical. The second reason for a suggested emphasis on determining the relationship between avian invasions and the crop cycle phase is the fact that many granivorous birds concentrate their feeding activities on fallen grain, often after harvesting is well underway, or even completed. At this time, because of the reduced vegetative cover of the crop, the birds now in large flocks, are more conspicuous than the small parties that alight to feed primarily on insects that are harmful during the growing season.

The balance between avian crop predation, and that on harmful agricultural pests is well illustrated in the familiar and widespread Baya or Weaver Bird (*Ploceus philippinus*). In the non-breeding season between October and March, flocks, often in company of sparrows and other granivorous birds, descend on paddy, sorghum, maize and millet several times a day, apparently causing immense losses. This crop damage however is spread over several square kilometres, reducing the intensity of damage to any one field. In the breeding season commencing with the onset of the monsoons, the diet of the Baya (in particular, nestling food) shifts almost completely to harmful insects like caterpillar, grasshoppers that are collected

intensively around a circumscribed area around nesting colonies, often located in the midst of agriculture. The male has a specialised social system described as 'successive polygyny' as a result of which he sires upto four females in separate nests, which may concurrently have 16 nestlings altogether (The young of the first clutch are also fed by each breeding male). Each nestling may be fed upto ten times a day by the female, who would be collecting insects from a limited area around the nest. Extrapolating these figures only for the two week period that the young birds are in the nest, it would be reasonable to expect that each breeding male is responsible for the destruction of approximately 2560 insects only for the period they are unable to feed themselves; in addition, the adults feed themselves almost exclusively on insects during this period.

A further perusal of these figures indicates that (very conservatively each family of Weaver birds - a male that consorts with 4 females and contributes to feeding the progeny of one would consume at least 6,300 insects in a month. The immense benefit that would accrue to a family community by several hundred pairs of weaver birds breeding in the locality is, then, many orders of magnitude greater than the damage caused by the consumption of a part of the standing crop in the non-breeding season. An accurate estimation of these figures under varying field conditions would add greatly to our understanding of the economic role of birds in agricultural eco-systems. In particular a quantitative and qualitative comparative estimation of crop and yield both when treated with pesticides when left to "natural" biocontrol by birds, would throw much light on this subject.

A PROPOSAL FOR THE BIOLOGICAL CONTROL OF RODENTS THROUGH THE USE OF HARMLESS REPTILES.

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Preamble

According to the Food & Agricultural Organisation of the United Natiuons (FAO, Rome), India loses about 20% to 25% of its food grains to rodents. We produce nearly 150 million tons annually. The loss is really large. Various effective measures have been taken to control the loss. Most of these are non-biological by way of chemicals and by mechanical means.

But the most important methods of biological control of Rodents by reptiles have not been highlighted. In this context, the following proposal could become significant, for the future.

Problem

Rodents destroy Agricultural produce and plantations of coconuts and fruit farms. Rodents multiply rapidly and are difficult to get at since their homes are usually burrows.

Areas of Loss

The standing crops, the warehouses and large storage areas, the lesser distribution centres and finally the domestic store rooms are the places where food grains and coconuts are destroyed.

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Existing Practices to Control and Need for Biolocial Control

Chemicals, rat poisons, traps, flooding, are some of the practices being followed. By this, the chemical poisons could affect the people and many species are developing resistance to chemicals. Hence there is a need for biological control of rodents by a method which does not affect the health of the people.

An Idea

Reptiles, birds, mammals etc have been known to destroy rodents without adverse effects to people. But due to commercial exploitation of snakes for their skin, monitor lizards for flesh and skin, 'and poisoning of land with chemicals affecting the birds and lesser mammals,all these have more or less contributed to an ecological imbalance. Hence why don't we try out an idea to achieve controllable limits to the population of rodents by the use of harmless snakes, monitor lizards etc?

The Problems to be Overcome

People are mortally scared of snakes, even of the harmless ones. Hence there is a need to educate the relevant people about the benefits and safety of the operation. Leaflets and photographs of children patting snakes, educating youngsters and school children help a lot to get over the fear of snakes.

The Proposal

I. The Biological control of rodents could be tried out in 3 different types of situations.

a) Agricultural fields of the wet crops.

b) Agricultural fields of the dry crops.

c) Coconut and fruit plantations.

d) Large and medium warehouses and domestic store houses.

II. The types of harmless reptiles and other animals to be used:

a) rat Snakes, (b) sand boas, (c) snakes belonging to the Racer family. There are of 3 types. These average 1 metre length and swallow prey of 2.5 'cm diametre. (d) Pythone, (e) Monitor Lizard, (f) Mongooses, (g) Barn owls, (h) Domestic cats.

III. Typical rodents to be destroyed: There are about 18 varieties of rats, Mica, Gerbills, Bandicoots. Out of these 5 species need particular control;. among them, the field Rat, is the predominant one. Another rat i.e. *Vandaluria* species is reported to destroy the coconuts.

IV. Typical agricultural fields of types described in I should be selected for a pilot project. The agricultural output in the above areas from past records should be computed. In all these areas special burrow types of caves and sandbeds should be constructed in the agricultural fields and plantations. Then, according to the types of rodents of the area, special snakes like the ones mentioned should be introduced, into the homes made for them. When once the homes are adopted by the reptiles, the control becomes easier. Specific observation posts should be constructed to observe the movement of the reptiles during nights. Monitor lizards usually climb up the coconut trees and check the numbers of special types of rats which destroy the flowers. Rat snakes hunt the rodents in their underground burrows. Mongooses should also be released into the gardens around the fields.

V. WAREHOUSES : Barn owls hunt rodents and also live inside the buildings. Similarly, small dense forest-type bushy areas could be created for releasing small pythons to destroy the bigger rodents like bandicoots around the warehouses.

VI. SMALLER WAREHOUSES : The gardens around could be used for release of mongooses and domestic cats.

VII. DOMESTIC HOUSES : Cats could be encouraged to control rodents.

In all the above schemes, the main idea should be acceptable to the local people. They should know the value of biological control of rodents. The benefits should be explained to them to so as diminish their unreasonable fear of snakes.

It should be made a people oriented project.

General Observations

As mentioned earlier, India loses an average of 20% to 25% of its foodgrains per annum due to rodents. This works out to one-fifth of the present production of 150 million tons i.e., the loss is 30 million tons of food grains per year. On an average, the cost of food grains works out to Rs 8,000/- per tonne. Hence the staggering loss is estimated at about 30 million x Rs 8,000/- (Rs 24,000 crores). These losses are exclusive of damages due to floods, drought, cyclones, fires etc. Rats, mice, and ban-

dicoots together have been declared as the enemy number one of mankind. If we are to keep up the pace of increased food production year after year there is a corresponding agency to control and bring down the explosion of the population of the above mentioned rodents since these follow "More availability of food, more number of rats" and thereby increased losses.

The information on the various types of rats, mice, and bandicoots have particular reference to the typical species, their habitant preferences, the feeding and breeding biology and the diurnal and nocturnal pattern of life and the prey-predator relationship is urgently necessary for evaluation and documentation, by research programmes. The existing information is not adequate and detailed studies have not been taken up due to the fact that the rodents mostly live underground. It is, therefore, proposed that detailed studies on the major types of rats, mice and bandicoots should be taken up and the possible methods of biological control experimented on various species in different food production areas like wetland, dryland etc,.

It may be however mentioned here that the introduction of some harmless reptiles such as snakes, monitor lizards and lesser mammals will definitely control the population explosion of rats.

The Madras Snake Park Trust would be happy to co-operate with the Agricultural Department in the choice of the sites for the pilot project and also help in monitoring it.

Some earlier schemes by the MADRAS SNAKE PARK TRUST

a) COCHIN SHIPYARD: The incident of 5 poisonous snake bites had created a labour problem. The MSPT was called to advise. and the area being large, a biological control programme was proposed. The problem arose due to the explosion of population of rats because of the left over food being thrown out near the canteens and living quarters etc. The principle is "More rats, more Snakes" and hence if the control of rats is implemented, it would reduce incidence of snakes. Therefore it is suggested that the release of rat snakes, mongooses, monitor lizards, barn owls etc will solve the problem to a great extent. This has been hailed as a unique measure. Education of the shipyard staff to remove

fear of snakes has also helped. It is understood that the situation is much better now. The objective has thus been largely achieved.

(B) LARGE LAND AREAS OF FACTORIES, SCHOOLS, COLLEGE AND DIFFERENT COMPANIES.: The MSPT has been continuously surveying against specific requests and also offering advice., wherever there is incidence of snake problem and as a result of such surveys suitable biological controls are suggested to the concerned people. The results are encouraging.

Conclusion

Since the overall results have shown that the Biological control of rodents has been successful it is our desire to share our experiences with peoples who are involved in this field and who are motivated to experiment with new ideas.

Scope of Biological Control

Scope for Biocontrol of Crop Pests to Prevent Environmental Pollution

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Abstract

Increased productivity of agricultural commodities has increased the problems like toxic hazards and environmental pollution due to harmful chemical insecticides. Though it might not be feasible to totally eliminate the use of chemical insecticides, there is every possibility of reducing their use by substituting them with ecoogically sound pest management techniques of which biological control is of considerable importance. Research on biological control of the last few decades in India has yielded several biocontrol techniques involving the use of entomophages and entomopathogens and, their prospects in the management of pests and the possibilities of reducing the use of chemical pesticides are discussed.

Introduction

Mounting pressure on land for increasing the agricultural production in India has led to introduction of high yielding but pest-susceptible crop varieties and hybrids. Indiscriminate use of toxic chemical pesticides for the management of crop pests has led to large scale pollution resulting in several hazards of life. With a view to reduce the magnitude of this problem several non-chemical methods of pest management have been developed of which biological control is one with great promise.

Harmful Effects of Chemical Pesticides

The use of synthetic organic pesticides have no doubt played a key role in increasing the agricultural production in India. But indiscriminate use and abuse of these compounds have led to several toxic hazards through pesticide residues in the food chain (Kalra and Chaula, 1981 ; Mehrotra, 1985). The hazards involved in handling and use of pesticides have also been well documented (Regupathy, 1988).

The potential risks to human lives around pesticide manufacturing units have been highlighted by Bhopal tragedy.

Apart from these problems, it is becoming increasingly difficult to manage the pests through the exclusive use of chemical pesticides. Repeated use of chemical pesticides tend to select pest population resistant to pesticides, tempting the farmers to often double the dose and frequency of application and aggravate the already existing environmental problems. The number of insect pests which have developed resistance to chemical pesticides have increased tremendously in the recent years. Several insecticides themselves are known to induce the resurgence of pests on crops (Jayaraj, 1987). Since most of the chemical insecticides are also highly toxic to the natural enemies of insect pests, the use of such chemicals upset the balance in nature leading to large scale outbreak of pests.

Biological Control - A promising alternative

Since the successful biological control of the cottony cushion scales *Icerya purchasi* using the predatory coccinelid *Rodolia cardinalis* in California and subsequently in India (Ramachandra Rao and Cherian, 1948), and the woolly aphid *Eriosoma lanigerum* by *Aphelinus mali* (Rahman and Khan, 1941) several natural enemies have been indentified for the biological control of pests.

Conservation of Entomophages

In a properly managed agro-ecosystem, many parasitoids and predators act on pest populations and keep them below those causing economic loss. However, the use of toxic chemical pesticides destroys many of these beneficials with the result, many pest species multiply rapidly causing considerable loss to crops. It has been shown that in a properly managed cotton field, the natural enemy populations were more in number and with minimum use of pesticides more yield of cotton could be realised (Sundaramoorthy, 1985).The use of broad spectrum pesticides on rice destroys potential parasitoids and predators resulting in the outbreak of pests like BPH (Chellaih, 1987). Hence, it becomes necessary to conserve these beneficials for better pest management for increased productivity.

Parasitoids and predators may be conserved by using selective insecticides like endosulfan which has been found to be relatively less toxic to *Trichogramma* spp. (Navarajan Paul et al., 1976) and *Chelonus blackburni* (Manoharan and Balasubramanian, 1982). Botanical pesticides particularly neem products which

have been found to be effective against several crop pests were found to be safe to the parasitiods and predators (Chelliah and Rajendran, 1984). Skip row application of deltamethrin on cotton conserved predators like *Chrysopa carnea* and *Menochilus sexmaculata* apart from reducing the pesticide load (Surulivelu, 1986). Eletrodyn application of insecticides has also been found to reduce the pesticides required for increasing the seed cotton yield and to reduce the harmful effect on the predatory coccinellids and predatory spiders.

The necessity for the use of toxic pestsicides can be reduced by enhancing the action of natural enemies, by creating favourable conditions for the entomophages as well as avoiding ecocidal pest control strategies like the use of light traps which also attract and destroy a large proportion of natural enemies (Mohan and Janarthanan, 1985).

Augmentative release of entomophages

Increasing the population of parasitiods and predators on the crops by artificial multiplication and release could have profound influence on the pest numbers. Successful control of several agricultural pests by the release of laboratory bred entomophages have been demonstrated. Examples of parasitoids and predators which were found promising against pests are furnished in Tables 1 and 2.

Parasitoids

Insect parasitoids have been extensively used for the management of insect pests of several agricultural crops. Notable among them is the egg parasitoids *Trichogramma chilonis* released inundatively for the suppression of the internode borer of sugercane *Chilo sacchariphagus indicus* (Sithanantham, 1980). T. *japonicum* has been found to be effective against the sugarcane top borer *Chilo exceptalis* (Sithanantham, 1980). An Ichneumonid wasp *Isotima javensis* was successfully used for the control of the top borer at Pugalur in Tamil Nadu (Raja Rao, 1964). The lepidopteran parasitoid *Epiricania melanolenca* when released at the rate of 4000 to 5000 cocoons or 4 to 5 lakh eggs/ha gave good control of the sugarcane Pyrilla (Misra et al., 1986).

Other species of *Trichogramma* viz., *T. braziliensis* and *T. chilonis* can also be used against pests of cotton (Yadav and Patel, 1987). The egg larval parasitoid *Chelonus blackburni* is another parasitoid used against cotton bollworm (Thontadarya and Jai Rao, 1977).

Notable success has been achieved in the biological control of the black headed caterpillar *Opisina arenosella* by the use of parasitoids like *Goniozus nephantidis* (Dharmaraju and Pradhan, 1976), *Eriborus trochanteratus* (Swamiappan, 1985) and *Brachymeria* spp. (Swaminappan and Jayaraj, 1978).

Fruit and Vegetable crops offer great scope for biological control of pests. The exotic parasitoid *Leptomastix dactylopii* successsfully controlled the mealy bug *Planococeus citri* in citrus plantations (Nagarkatti et al., 1987). The use of the exotic eulophid *Aphelinus mali* for the control of the apple wooly aphid *Eriosoma lanigerum* is another good example (Verma and Singh, 1985). *Encarsia perniciosi* has been successfully employed for the control of the san jose scale *Qudraspidiotus perniciosi* a serious pest of apple, peach and other temperate fruits (Sahai and Joshi, 1965).

Predators

Several predator insects and mites have also been used in biological control of pests. The notable among them are the predataing coccinellids *Rodolia cardinalis* used against the cottony cushion scales *Icerya purchasi* (Ramachandra Rao and Cherian, 1948), *Cryptolaemus moutrouzieri* (Mani and Thontadarya, 1987a) *Scymnus coccivora* (Mani and Thontadarya, 1987b) released for the control of the grape mealy bug *Maconellicoccus hirsutus*. Several other coccinellids have been employed against the sugarcane scales (Table 2).

Among the hemipteran predators *Platymeris laevicollis* used for the control of *Oryctes rhinoceros* (Anon., 1985) and the mirid bugs *Cyrtorhinus lividipennis* which has great control potential against the rice BPH (Singh, 1988) are important.

Predatory mites like *Phytosieulus persimilis* which has been extensively used in other countries for the management of spider mites was introduced into India and when released inoculatively on okra successfully established and controlled *Tertanychus ludeni* (Krishnamoorthy, 1987).

Apart from these parasitoids and predators which have been used in the field for biological control, several others which have great potential against crop pests have been indentified. The mass production techniques for these entomophages are being developed so that they can be employed in biological control programmes.

Role of entomopathogens

Several entomopathogenic organisms have been employed for the management of pests on crops. These are termed as microbial pesticides or biological pesticides since they are of natural origin and their mode of action is other than direct toxicity. These consist primarily of viruses, bacteria fungi and protozoa and notable examples of successful use of these organisms against crop pests are given in Table 3.

Viruses

Of the several microbial insecticides developed viral insecticides are of considerable interest. The baculoviruses comprising of the nuclear polyhedrosis (NPV) and granulosis viruses (GV) have been found to be effective against several pests. The methods of mass production, formulation and field application have been standardised. The efficacy of these viruses can be increased by the use of certain adjuvants like crude sugar (Rabindra and Jayaraj, 1988a). The NPV has been found to be compatible with several insecticides including endosulfan application of half of the recommended dose of endosulfan. (Rabindra and Jayaraj, 1988b). Botanical pesticides were found to increase the efficacy of NPV against *Heliothis armigera* and *Spodoptera litura* Methanolic extracts of *Ocimum sanctum, Acorus calamus* and *Catharanthus roseus* as well as water extracts of neem seed kernel extract increased the efficacy of NPV against *H. armigera* and *S. litura* (Rabindra et al., 1988). NPV can also be used along with other biocontrol agents like the parasitoid *Campolitis chorideae* without any drawbacks (Annon., 1983). *C. Chloridea* was found to transmit the virus to *H. armigera* (Odak et al., 1982).

NPV of *Heliothis armigera* and *Spodoptera litura* has also been developed into dust, wettable powder and ULV formulations (Ethiraju, 1986; Muthiah, 1988). The ULV formulation of *H.armigera* was found to be safe to certain parasites, predators, honey bees, silk worm and white rat (Muthiah, 1988). The baculoviruses are in general very specific and several of them have been studied extensively for their safety to non target species and found to be safe.

Of the several granulosis viruses reported from India, only the GV of *Chilo infuscatellus* has been studied for its field control protential. The virus was found to be as effective as endosulfan or carbofuran (Easwarmoorthy and Santhalaxmi, 1988).

Bacteria

The spore forming crystaliferous bacterium *Bacillus thuringiensis* (B.t.) is one of the most useful microbial insecticides tested in India. It has been found to effectively control several agricultural pests like *Plutella xylostella* the diamond back moth which has developed resistance to several insecticides (Table, 3). Becuase of the quick knockdown effect produced by the crystal toxin and wide host range, B.T. is of considerable importance particularly in the management of lepidopterous pests. Adjuvants like whole egg homogenate at 0.1% and whole milk 0.5% increased the efficacy of B.t. against *P. xylostella* on cauliflower Neem seed kernel extract 5% and C. *rosus* extract 3% increased the efficacy of B.T. (Justin, 1987). B.t. can also be combined with other microbials like NPV for better control of *S.litura* (Komolpith, 1975).

Fungi

Among the fungal pathogens, the green muscardine fungus *Metarhizium anisopliae* which can be easily multiplied in the laboratory in carrot medium has been effectively used against the rhinoceros beetle of coconut *Oryctus rhinoceros*. Application of the fungus in the manure pit killed all the stages of the pest (Sundarababu et al., 1983). The white halo fungus *Verticillium lacanii* produced on sorghum grains and applied on coffee plants during the monsoon seasons in the lower pulney hills effectively controlled the coffee green bug (Easwaramoorthy and Jayaraj 1978). *Beauveria brougniartii* was effective against *Holotrichia serreata* in grapevine (Jayaramaiah, 1981).

Protozoans

Eventhough there are several reports on the occurrence of protozoan infection of crop pests in India, not much work has been done on the field control of the pests. Rabindra (1979) found that *Farinocystis tribolii* can be used in wheat flour for the suppressions of the red flour beetle *Tribolium castaneum*. The protozan infection also increased the susceptibility of larvae of *T. castaneum* to several insecticides (Rabindra et al., 1988) indicating that the pest can be managed with even low doses of pesticides if they are predisposed to infection.

Nematodes

Among the entomophilic nematodes that have promise in the control of crop pests, *Steinernema feltiae* (DD 136 strains) has been found to have a great potential. Soil application of the nematodes controlled the chaffer grubs *Anomola* sp. which is a

serious pest of many crops in the Nilgiris, (Rajeswari Sundarababu et al., 1984). This nematode was also found to be highly effective against larvae and pupae of *S. litura* (Narayanan and Gopalakrishnan, 1897). Recently at the Tamil Nadu Agricultural University an Indian strain of *Heterorhabditis bacteriophora* isolated from the Nilgiris has been found to have a wider host range and high virulence to crop pests such as *H.armigera* and *S.litura.*

Role of Biological Control in IPM

The scope for biological control particularly in IPM is quite bright. Several of the biocontrol agents discussed in this review can be utilised either as sole control agents or as components of IPM. Through the proper use of these biocontrol agents, the amount of pesticides used on agricultural crops can be appreciably reduced on crops like cotton which consume a lot of pesticides. Though cotton occupies only 5% of the total cultivated area it consumes more than 55% of the pesticides used in our country. Efficient use of biocontrol agents for the management of cotton pests can reduce the pesticide consumption by at least 30% which means a reduction of about 15% of the total pesticide consumption. Proper and intensive use of biocontrol agents for the management of pests on other crops can lead to further reduction in pesticide use in our country as a result of which we will have a better environment to live in.

The Tamil Nadu Agricultural University is launching in a big way to develop parasitoids, predators and pathogens for the management of pests of agricultural crops. Techniques of mass production, formulation of microbial insecticides and methods increasing the efficacy of the biocontrol agents in the different agroecosystem are being developed. Simultaneously cropping systems more suitable for entomophages and entomopathogens are being identified. For example, intercrops for pulses and oilseeds which enhance the action of natural enemies have been identified. If the IPM practices involving biological control are properly blended into the crop production systems, crop yields can be substantially increased with minimum use of chemical insecticides. Of course certain pests are amenable for control with the exclusive use of biocontrol agents which means no pesticide pollution of our food and environment.

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Table 1: Selected references on parasitoids found promising against some crop pests in India

Crop & Pest	Parasitoid	References
Sugarcane		
Internode borer: *Chilo sacchariphagus* indicus	*Trichogramma chilonis*	Sithanantham and Navarajan paul (1978) Maninder and Verma (1981)
Top borer: *Chilo excerptalis*	*T.japonicum* Isotima *javensis*	*Sithanantham (1980)* Kalra and David (1964)
Shoot borer: *Chilo infuscatellus*	*Sturmiopsis inferens*	David et al. (1980)
Pyrilla perpusilla	*Epiricania melanolenca*	Misra et al. (1986)
Tomato fruit borer: *Heliothis armigera*	*T.braxiliensis* *T.Chilonis*	*Anon. (1985)* Yadav and patel (1987)
Cotton		
H.armigera	*T.braziliensis*	Sangwan et al. (1972)
Bollworms:	*T.braziliensis* and *Apanteles angaleti*	Kandage et al.(1980)
Castor capsule borer: *Dichocrocis punctiferalis*	Eriborus trochanteratus	Swamiappan (1985)
Coconut black headed caterpillar:	-- do --	-- do --
Opisina arenosella	*Goniozus nephantidis*	Sundaramoorthy and Santhanakrishnan (1979)
	Brachymeria spp.	Swamiappan and Jayaraj (1978)
Citrus mealy bug., Plannococcus citri	*Leptomastix dactylopii*	Nagarkatti et al. (1987)
Apple wooly aphid, Eriosoma lanigerum	*Aphelinus moli*	Verma and Singh (1985)
Sanjose Scale *Quadraspidiotus periciosus*	*Encarsia perniciosi*	Sahai and Joshi (1965)

Table 2:
Selected references on predators found promising against some crop pests in India.

Pest	Predator	References
Cottony Cushion scale *Icerya purchasi*	*Rodolia cardinalis*	Ramachandra Rao and Cherian (1948)
Grapevine mealy bug *Maconellicoccus hirsutus*	*Cryotolaemus montrouzieri*	Mani and Krishnamoorthy (1988)
	Scymnus coccivora	Mani and Thontadraya (1987)
Pomegranate and custard apple mealy bugs	*C.montrouzieri*	Anon. (1987)
Sugarcane scales : *Melanaspis glomerate*	*Chilocorus nigritus*	Sheshagiri Rao (1980)
	Pharascymnus horni	
	Lindorus lophantae	Lakshminarayanan(1983)
Internode borer *Chilo sacchariphagus indicus*	*Camponotus spp*	Easwaramoorthy et al., (1984)
	Oecophylla smaragdina	
	Solenopsis geminate	
Coconut Rhinoceros beetle: *Oryctes rhinoceros*	*Platymeris laevicollis*	Anon. (1985)
Rice BPH *Nilaparvata lugens*	*Lycosa pseudoannulata*	Rajendran (1987)
	Cyrtorhinus lividipennis	Singh (1988)
Spideer mites *Tetranychus ludeni*	*Phytosieulus persimilis*	Krishnamoorthy (1987)
T.urticae		

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Table 3: Some important examples of microbial control of insect pests in India.

Pathogens	Pest	Crop	References
VIRUSES			
Nuclear Poly hedrosis Virus	*Heliothis armigera*	Chickpea	Rabindra and Jayaraj (1988b)
		Pigeonpea	Santharam et al. (1981)
		Lablab bean	Jayaraj et al (1987)
		Cotton	Dhandapani et.al. (1987)
		Sunflower	Rabindra et al. (1985)
	Spodoptera litura	Cotton	Jayaraj et.al. (1980)
		Tobacco	Rao et.al. (1987)
		Blackgram	Mahadevan and Kumaraswamy(1980)
		Cauliflower	Chaudary and Ramakrishnan(1980)
		Groundnut	Sachidanandam (1988)
	Adisura atkinsoni	Lablab bean	Narayanan(1987)
	Amsacta albistriga	Groundnut	Jayaraj et.al. (1977)
	Opisina arenosella	Coconut	Philip (1985)
Granulosis Virus	*Chilo infuscatellus*	Sugarcane	Easwaramoorthy and Santhalaxmi(1988)
BACTERIA			
Bacilus thuringiensis	*Plutella xylostella*	Cabbage	Narayanan et.al.(1970)
		Cauliflower	Justin (1987)

Pathogens	Pest	Crop	References
	Spodoptera litura	Castor	Govindarajan et.al. (1976)
	Papilio demoleus	Citrus	Narayanan and Jayaraj (1974)
FUNGI			
Metarhizium anisopliae	*Oryctes rhinoceros*	Coconut	Sundara Babu et.al. (1983)
Verticillium lecanii	*Coccus viridis*	Coffee	Easwaramoorthy and Jayaraj (1978)
Beauveria brongniartii	*Holotrichia serrata*	Grapevine	Jayaramaiah (1981)
PROTOZOA			
Farinocystis tribolii	*Tribolium castaneum*	Wheat flour	Rabindra (1979)
NEMATODES			
Steinernema feltiae	*Anomala sp.*	Potato	Rajeswari et.al. (1984)

RECOMMENDATIONS

The following suggestions were made and discussed from the point of view of follow-up action:

1. Comprehensive documentation of traditional biological pest control techniques must be made, both from literary sources as well as people's practice. There should be a resource centre established for this purpose and this centre should popularise this information amongst the farmers as well as the scientists.

2. Even though the TNAU has many centres where research in biological control is being done, the out come of such research is not easily accessible to the farmers. Steps should be taken to rectify this lacuna.

3. Effective pest control without chemical pesticides is not consistent with the modern chemical-based farm technology. Alternatives in the form of natural and organic farming should be developed and popularised to make large-scale biological pest control possible.

4. The problem of feeding our increasing population can be greatly eased if tree-farming is extensively adopted - trees that give food, fodder and fuel. Research and experimentation in this direction should be intensified.

5. A permanent body, like a registered society, should be set up exclusively to deal with propagating and popularising the ideas and techniques of biological pest control. Starting of an all-India news-letter, net-working of various active groups, agencies and individuals etc, should be taken up. A small working group has been constituted to take and finalise these matters and the PPST Foundation would follow it up.

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